Science and Technology

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Science and Technology

Changes We Make

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As You Begin

Each morning you awake to a new day. The Sun lights the day and warms the things around you. In the spring and summer, flowers and trees bloom. These are some of the things around you that change. Yet you have little if anything to do with these changes.

But there are some changes only you and other people can make. If it is dark, you can turn on a light. If it is cold, someone may turn on the heat or light the furnace. Each day you use the discoveries of scientists and the inventions based on these discoveries. You may use the telephone or watch TV. You may even use a computer.

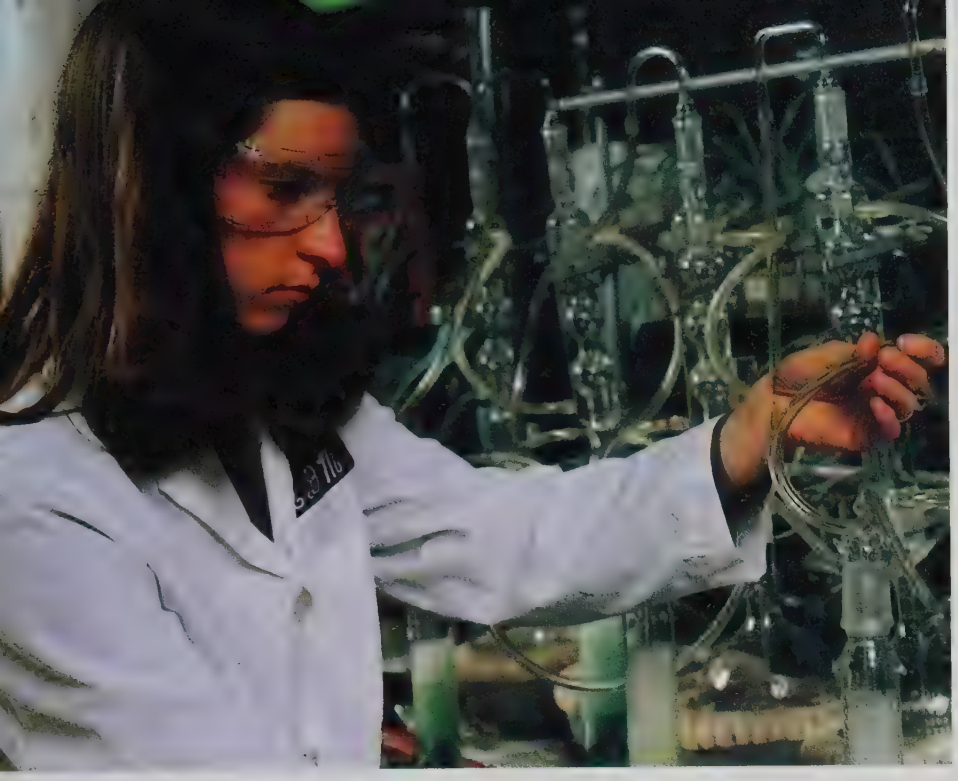
In the past 200 years, there have been many changes in the way people live. Even as you read, new and useful things, such as lasers, are being developed. Because of these changes you may live a longer and healthier life. Because of these changes, you may also learn more and do more.

This year's work will introduce you to many of the changes you can make. You will do many investigations that will help you understand these changes. Of course, you won't study all the changes you can make. After all, you are only at the beginning of your work in science.

Changing Matter

Will the ice change? How do you know? Study the picture. You have *observed* what the picture shows again and again. Surely you have seen ice changing. You have also seen other ways that things change.

Suppose we observe a change many, many times. Suppose each time we observe the change, it happens the same way. May we not *predict*, or tell ahead of



Unit 1

time, what will happen if we observe the change once again?

This scientist is observing a different kind of change. She has observed this change many times before. Can she predict what will happen the next time? Why?

In the next few weeks, you will observe some changes. Then you will make some of these changes yourself. You may also be able to predict what changes will take place. As you do these things, you will be using some of the ways of the scientist.

1

All Around You— Matter

Look at this ship inside a bottle! Is there anything else inside the bottle? At first you might say no. But think about it for a moment. Maybe there is something you can not see. By the way, how did the ship get inside the bottle? Try to find out.

A

Taking Up Space

Observe the bottles in the photograph. Notice that bottle **A** is open. Bottle **B** is closed with a cork. Bottle **C** is filled halfway with water. Bottle **D** is filled halfway with pebbles.

Study bottles **C** and **D** again. What fills the other half of these bottles? Nothing?

Observe bottles **A** and **B.** They look empty. Are they really empty? Let's find out.

Turn an empty bottle upside down. Push it down under the water. What happens?

Does water go into the bottle? Why not? What keeps the water out?

Take an empty bottle. Close it with a cork. Push the bottle under the water. But hold it up, not down.

Now open the bottle. What happens? Bubbles appear as the bottle fills with water. What could the bubbles be made of?

Are empty bottles really empty? No doubt you must have come to the idea that there is air in an empty bottle.

Water, a Brick, and You

Slide a brick into some water. Gently! Gently! Don't splash the water. First mark the level of the water. Then slide the brick in. The water level rises. Why? Easy. The brick takes up space.

Does the brick have weight? To find out, you can weigh the brick on a scale.

A brick has weight. It takes up space. So does water. So does air. So does a ship. So do you. You, air, water, a brick, and a ship are all **matter.** *Matter is anything that has weight and takes up space.*

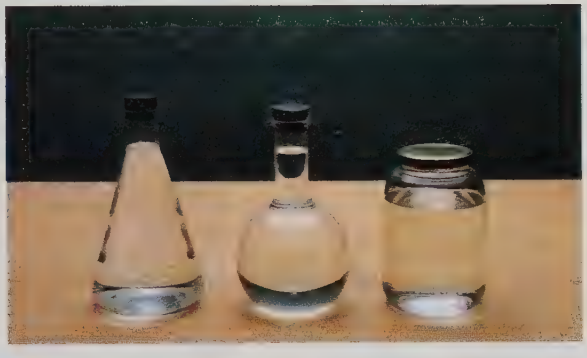
Things You Know

1. What is in an empty bottle?
2. What is matter?
3. How can you show a rock is matter?

Alike, Yet Different

Air, water, and marbles are alike in one way. All of them have weight and take up space. All of them are matter. Yet all are different. Air is a *gas.* Water is a *liquid.* A marble is a *solid.* So air, water, and marbles are different. How are they different?

Study the pictures. What kind of matter do you see in each picture?



Suppose you put some solid matter on a table. A pencil will do. You know the shape of the pencil doesn't change.

Suppose you put some liquid matter on a table. Water will do. How does the shape of the water change?

Observe three liquids and three solids. Study their shapes. For liquids, milk and juice will do. You pick a third liquid. For solids, try a glass and a chair. Pick another solid to observe.

You may have some trouble observing a gas. Yet there is a gas in the room you are in. Breathe in. Take a full, deep breath. You are breathing air. How much of the room does the air fill?

Compare your observations with these:

- A gas has no shape. It spreads to fill whatever it's in.
- A liquid has no shape either. It takes the shape of whatever it's in.
- A solid has its own shape. It keeps its shape no matter what it is in.

Kinds of Matter Around You

Scientists try to understand the world around them. When scientists observe things around them, they ask questions. They may have asked: What kinds of matter are there? You now have one answer to that question. You know matter can be a solid, a liquid, or a gas.

This morning you may have taken a walk. You stepped on solid matter—on a sidewalk or a path. Perhaps you ran across a field.

You'll agree it would be hard for you to walk on a gas or a liquid. But you may have been on skis or skated on ice. Then you know that you can skate on solid water.

Ice and snow are both water, but snow is fluffy. Ice is hard. We say ice and snow have different **properties.** A property of matter helps us tell what kind of matter it is.

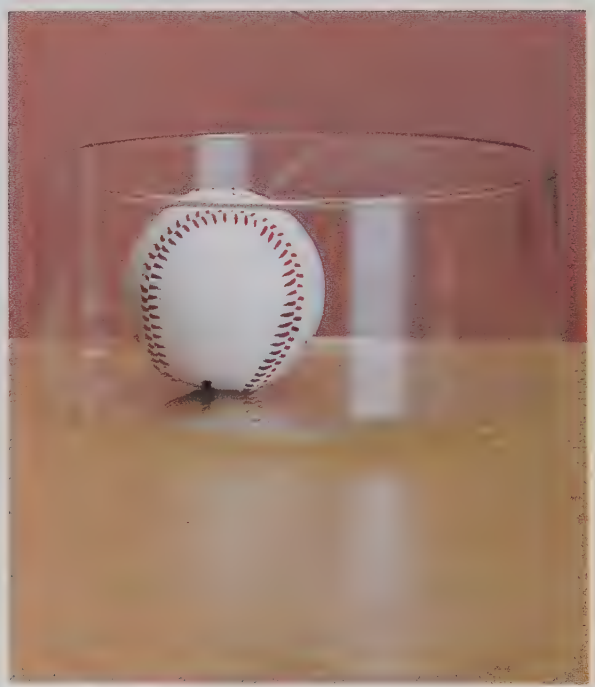
property (präp'ərt·ē)

A property of ice is that it is hard. A property of snow is that it is fluffy. Liquid water has different properties. It pours out of a bottle. It flows. It is wet. Ice and snow aren't wet until they melt.

Scientists often put things in groups. They use properties to help group things. In this way, scientists **classify** things. To group things is to classify them. When we classify things we can talk more easily to others about what we observe.

classify (klas'ə·fī)

Suppose someone says a thing is a liquid and not a solid. Of course, you wouldn't know which liquid it was. But you would have some idea about it. Even if you never see this liquid, you may see a picture of it in your mind. Which of these pictures would you see in your mind?



Look around you. Everything around you makes up your **environment.** So everything in your environment is made up of matter.

environment (in·vī'rən·mənt)

1. Into what three groups can you classify the matter in your environment?
2. How do the properties of ice change when it melts?
3. How can you show that some matter is a liquid?

A Project: Is It a Solid or a Liquid?

Perhaps you have played with silicone putty. How would you classify it? You might want to try these activities before you decide.

First roll some putty into a ball. Then try to bounce the ball on a table. Does the ball hold its shape when you bounce it? Leave the ball in a dish overnight. What happens to the ball?

Put a ruler across the top of a tall jar. Roll a piece of putty into a rod about 8 centimeters long and 1 centimeter thick. Bend the rod into a U shape and place it on the edge of the ruler as shown. Wait about 20 minutes. What happens to the putty? Would a solid flow into the jar?

Is silicone putty a solid or a liquid. It's not always easy to classify matter.

Changes in Matter

Suppose you put a metal pan on a hot plate. You hold a cold, hard ice cube on a fork over the pan. You know the metal pan will get hot. What will happen to the ice cube?

Drop by drop, the solid ice cube melts. It turns into a liquid–water.

As the drops hit the hot pan, the drops get hot. They boil away. The drops of water disappear into the air. The water becomes a gas. You can not see the gas. It is invisible. This invisible gas is called *water vapor.*

What happened to the ice cube? The solid ice cube changed into liquid water. In turn, the liquid water changed into a gas–water vapor. This change in matter is called a **change of state.** Let's see why.

A rock is matter in a solid state. Water is matter in a liquid state. Air is matter in a gaseous state. A solid is a state of matter. A liquid is a state of matter. So is a gas. All matter is in either a solid, a liquid, or a gaseous state.

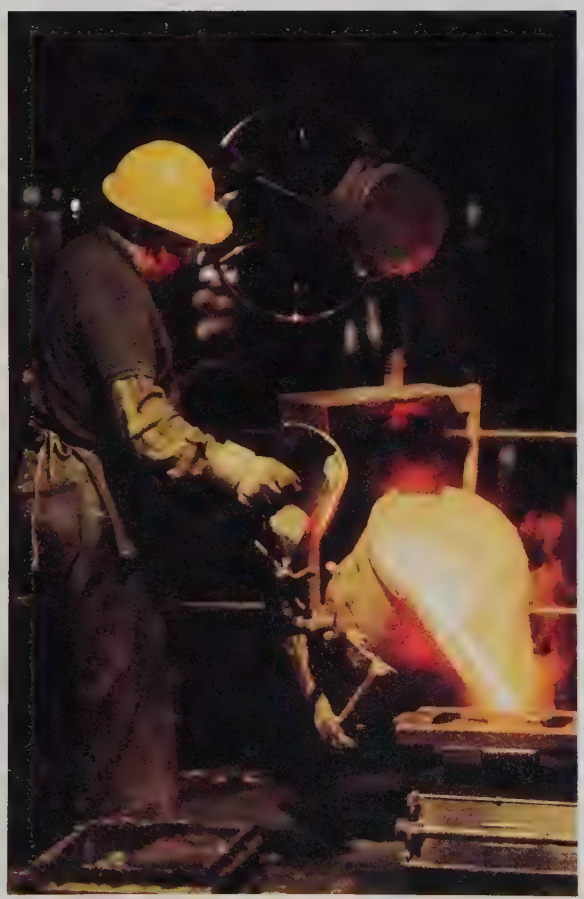
Matter can change its state. It can change from a solid state to a liquid state. It can also change from a liquid state to a gaseous state.

Matter can even change its state from a gas to a liquid. Suppose some water boils in a kettle. A cool saucer is placed just where you *can not* see the steam. That's where the water vapor will be. Observe what happens when the water vapor hits the cool saucer.

When you go home, place a cup of water in the freezer. What do you **predict** about the water? To predict, remember, means to tell ahead of time what you think will happen.

Perhaps someone you know works in a steel mill. Or you may have seen something like this on TV. Look at what is being poured. It's liquid iron. Yes, iron can be made so hot that it pours. This liquid iron will be used to make solid steel. The steel will then be used to make many different things.

Gold is another metal that can be melted and poured. Gold can form solid blocks when it cools. So can other metals such as silver, copper, aluminum, and lead.



Now you know heat can melt solids and change them into liquids. You saw that heat can also change liquids into gases. What can change liquids into solids?

When gases are made cold enough, they can change into liquids. You know that cooled water vapor changes into liquid water. Why can you see the child's "breath" in the picture?

You may know oxygen is one of the gases in air. This rocket uses liquid oxygen. The oxygen is so cold it can be poured.

Liquids can be made cold enough to turn into solids. Look at the beard of the explorer. Water vapor changed to liquid water. Liquid water changed to ice.

Look at the lava streaming down the side of this volcano. Lava is hot, melted rock. Great heat inside the Earth melts the rock. Hot rock and gases shoot out from the volcano. Predict what will happen when the hot lava comes in touch with cool air.

Things You Know

1. What happens when lava from a volcano changes its state?
2. What gas does water change into when it boils?
3. Predict what will happen if you heat some snow in a pan.

Using What You Know

Write the answers to all questions in your science notebook.

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term.

1. A property of ice is that it is (hard, fluffy).
2. A rock is matter in the (liquid, solid) state.
3. When water becomes a gas, the gas is called (oxygen, water vapor).
4. When you classify things, you put them in (groups, changes of state).
5. When liquids are cooled enough, they can be changed into (solids, gases).
6. All matter takes up space and (has weight, is empty).
7. Matter that takes the shape of whatever it is in is a (gas, liquid).
8. Everything around you makes up your (properties, environment).
9. When steam hits a cold plate, the steam changes into a (liquid, solid).
10. The hot, liquid rock that streams from a volcano is (metal, lava).

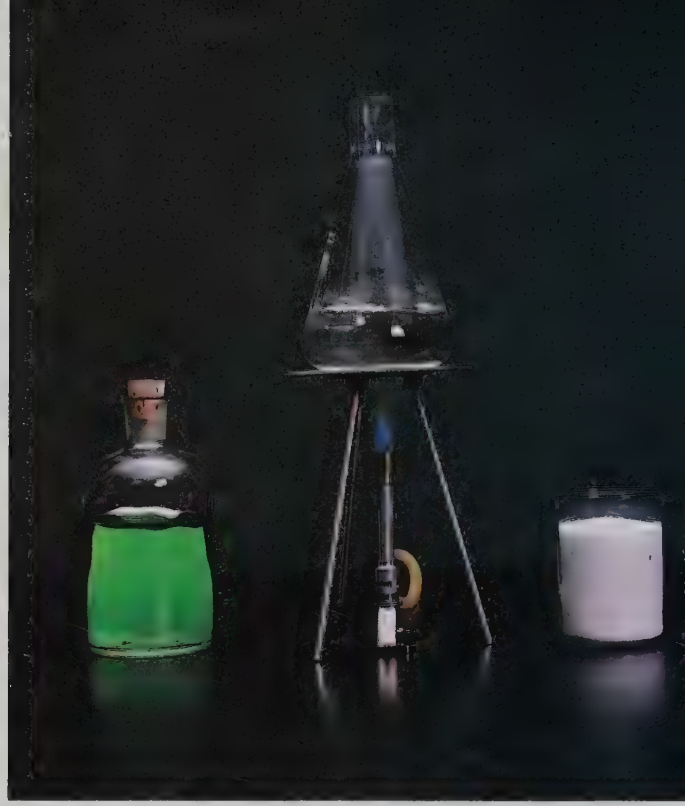
B. Predict what will happen to the matter in each picture below.

11.

12.

2

A Closer Look at Matter



You know scientists classify matter into three groups: solids, liquids, and gases. But scientists keep asking questions. Perhaps you have asked yourself this question: What are solids, liquids, and gases made of?

A

Bits of Matter

A long time ago, a Greek named Democritus asked himself the same question. Democritus wondered what matter was made of. He wondered what would happen if he cut a solid sheet of gold into very small bits.

Well, gold costs a great deal. So suppose you use a different kind of metal. Perhaps you have used metal foil like this for cooking or for storing food. The foil is made of the metal aluminum.

Now suppose you take a scissors and cut a piece of aluminum foil. And then you cut it again, and again.

If you keep on cutting the foil, what would you have in the end?

Democritus thought you would have a very, very, tiny, tiny bit. It would be too small for anyone to see. He called this tiny bit an **atom.**

An aluminum atom is the smallest bit of which aluminum is made. A gold atom is the smallest bit of which gold is made. In fact, Democritus thought an atom is the smallest bit of which all matter is made.

Scientists often use another word for matter. They use the word *substance.* A subtance can be a solid, a liquid, or a gas. Aluminum is a substance. So is water. So is air.

More About Matter

Some substances are made up of only one kind of atom. These substances are **elements.** Aluminum is an element. Aluminum is made up of only aluminum atoms. Gold is an element. So is the oxygen in air. So is the carbon in coal.

Look at the liquid inside the thermometer. The liquid is the element mercury.

These lights use the element neon. Neon is a gas that glows red when electricity passes through it. Surely you have seen many neon signs.

Things You Know

1. What is the smallest bit of which carbon is made?
2. Why are gold and oxygen called elements?
3. How are the elements mercury and neon used?

Mixing Elements Together

By now you may be wondering whether elements can be mixed together. In a way, you have made a **mixture** of elements many times.

mixture (miks'chər)

Have you ever kept paper clips and nickels together in your pocket? Perhaps you know that paper clips are made mainly of the element iron. Nickels are made mainly of the element copper. How can you separate the clips from the nickels without touching them?

Pass a magnet over the mixture of clips and nickels. Do you get the results shown in the picture?

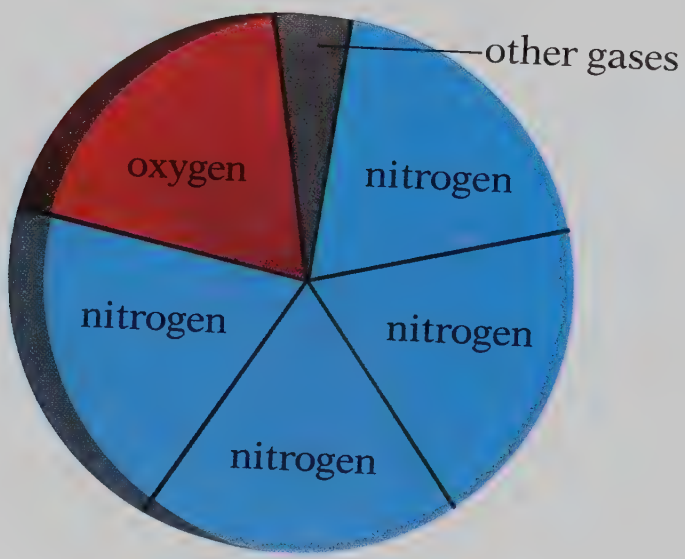
Air–A Mixture of Elements

Suppose you have a jar of air. Think of what you know about air. You know that air is matter. It has weight. It takes up space. You know air is not a solid or a liquid. It is a gas.

Air is really a mixture of different gases. This air mixture is harder to separate than a mixture of clips and nickels. But scientists have found that air is made up mostly of two elements. These elements are nitrogen and oxygen.

Draw a circle. Let it stand for air. Think of the circle as a pie. If you slice the pie, five of the slices would be about the same size. Four of these slices would stand for nitrogen. How many slices would stand for oxygen?

Gases in Air



The pie is called a *pie graph.* A graph is a picture that shows information.

So air is about one part oxygen, and four parts nitrogen. The last part of the pie is the smallest. It stands for the other gases in air. You already know one of them, water vapor.

Get a tall, narrow jar and some steel wool. Push a piece of steel wool into the bottom of the jar. Careful! Don't pack the steel wool too tightly.

Fill the jar with water. Then empty the jar. This wets the steel wool inside.

Now place the jar upside down in a large glass of water. Notice the water level inside the jar.

Leave the jar in the glass of water for several days. Observe it each day. What happens to the steel wool?

What happens to the level of the water inside the jar? Explain why the amount of air inside the jar changes.

Where Does the Air Go?

You may know that steel wool is made mainly of the element iron. Iron rusts. It rusts best when it is in a mixture of air and water. The water in the glass kept the air and the iron in the jar damp.

The iron in the steel wool joins with the oxygen in the air. The steel wool rusts. As the steel wool begins to rust, the water starts creeping up inside the jar. Let's try to find out why.

You know air is a mixture of gases. The oxygen in the air is used up when rust forms. The water goes into the jar to take the place of the oxygen that was used.

Once again, observe the jar with the steel wool in it. Here is a jar that one class used. Notice there is still a lot of gas left in the jar. Just one part of the air has been used up. That part of the air was oxygen. Four parts of the air are left. These four parts are nitrogen.

Things You Know

1. What gas in the air is used up when an iron nail rusts?
2. Air is about one part oxygen. What gas makes up the other four parts?
3. How can you separate a mixture of paper clips and paper without touching it?

A Book For You:

Air is surely one of the most common mixtures in your environment. Yet there are many other mixtures around you. *Gobs of Goo,* by Vicki Cobb, published by Lippincott, Philadelphia, 1983, introduces you to some of these mixtures. This book not only includes colorful pictures, but also describes various activities that are easy for you to do.

Joining Elements Together

Let's see what happens when the element iron joins with the element oxygen. A new substance–rust–is formed. We say the two elements combine. When iron combines with oxygen, rust is formed.

Scientists use the name iron oxide for rust. Look for the word oxygen somewhere in the name. Yes, oxygen is in the word oxide.

Elements can combine to form new substances. The new substances are called **compounds.** Iron oxide is a compound. A compound is made of two or more elements.

compound (käm'paund)

You know an element is made up of just one kind of atom. A compound is made up of atoms of two or more elements.

Mixtures and Compounds

You know elements can form mixtures. You know elements can form compounds. How are mixtures different from compounds?

When you mixed clips and nickels, the clips did not change. The nickels did not change. If you mix sand and marbles, the sand does not change. Neither do the marbles. In a mixture, substances do not change.

When the compound iron oxide forms, the steel wool changes. The air inside the jar also changes. When elements join to make a compound, the elements change. The elements combine to form new substances.

Water–Element or Compound?

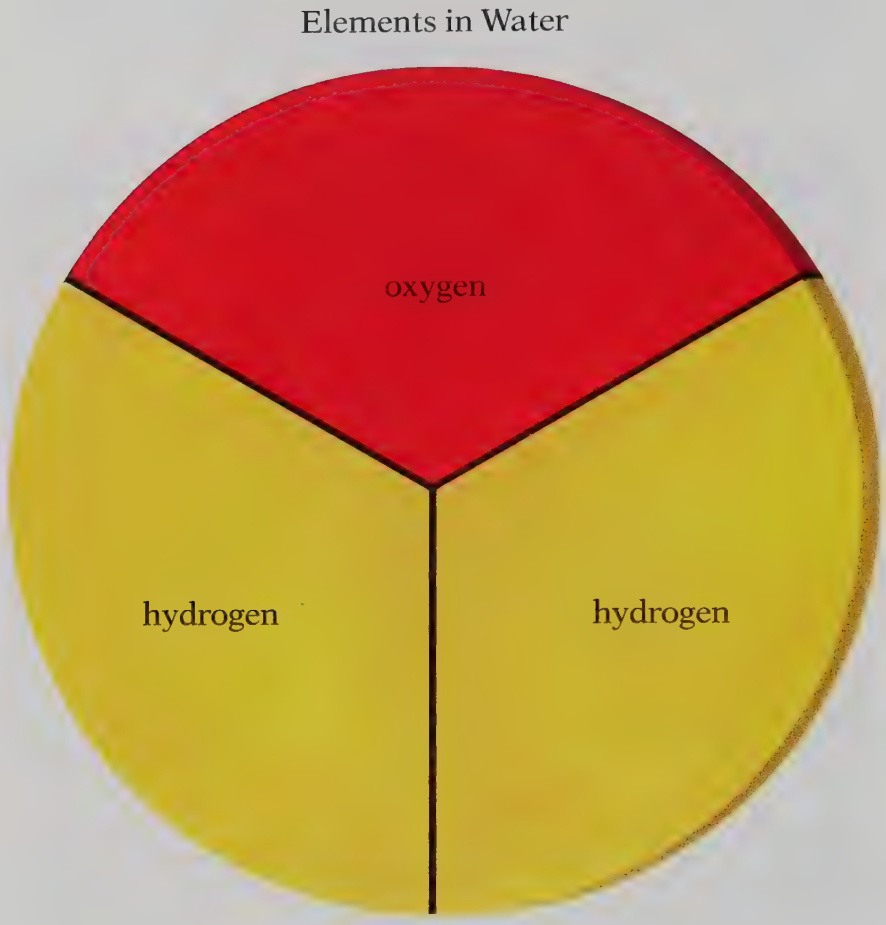
Water is just a tiny part of our air, but oh so important. We could not live without water. We would have no rain. The soil would not have water. Plants could not grow. We could not grow food.

Let's see what water is made of. Is it an element or a compound? Observe what happens when electricity is passed through water in a special way.

The electricity breaks down the water. Two gases are formed. One gas goes to one tube. A different gas goes to the other tube.

The gas on the left is the element oxygen. The gas on the right is the element hydrogen. More hydrogen is formed than oxygen. About how much more? You see there is twice as much hydrogen as oxygen.

Suppose we use a pie to stand for water. Two slices would stand for hydrogen. Wouldn't one slice stand for oxygen?



Water is made up of two parts hydrogen and one part oxygen. How interesting! Two gases combine. They change. They form a new substance—a liquid. The elements oxygen and hydrogen combine to form the compound water.

As you go on in science, you will study more about the way elements combine. You will also learn more about the way scientists work.

Things You Know

1. What is a compound?
2. Is iron oxide a mixture or a compound? Why do you say so?
3. How can you show that water is a compound and not an element?

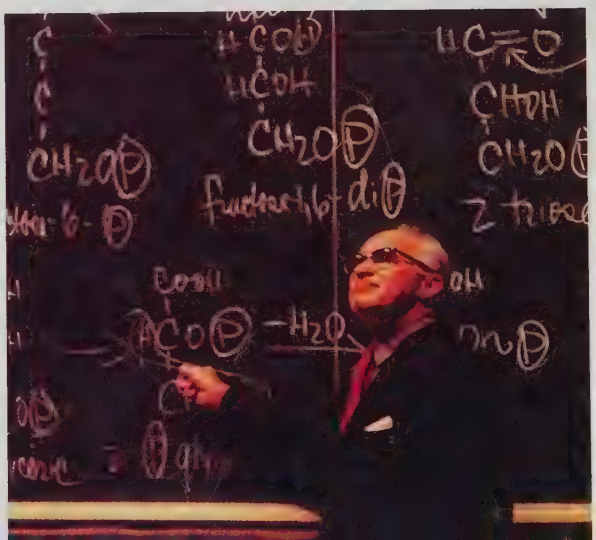
Careers: In Chemistry

People who work in chemistry study the substances in matter. They study how these substances change. They try to find out why certain changes take place and how to control them.

Some chemists do research to learn more about the elements and compounds of the Earth. They try to develop new compounds, such as plastics, medicines, and fuels, that we can use. Laboratory technicians may use special equipment to analyze matter. That is, they try to find out what elements and compounds a substance is made of.

Some people sell the products that have been developed. Other people write reports of experiments and books about chemistry.

Of course, someone must help others to learn about and understand chemistry. Perhaps you'd like to be a chemistry teacher someday.



Chapter 2

Using What You Know

Write the answers to all questions in your science notebook.

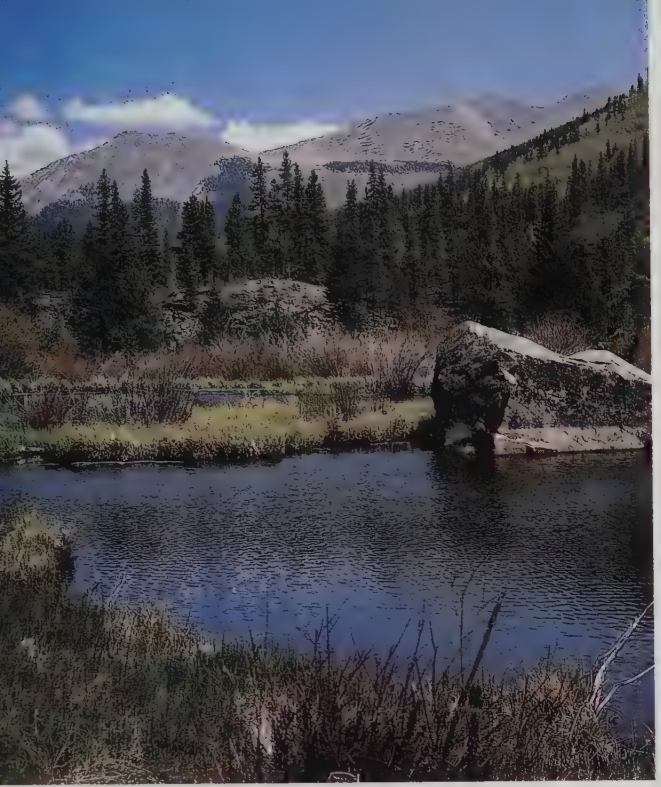
A. Read each sentence. Use terms from the list below to fill in the blank spaces. You may use a term more than once.

atom, compound, element, hydrogen, iron oxide, mixture, nitrogen, oxygen

1. The smallest bit of which gold is made is a (an) _____.
2. A substance made up of only one kind of atom is a (an) _____.
3. Oxygen is a (an) _____.
4. Air is a (an) _____.
5. Air is about one part oxygen and four parts _____.
6. Two elements can combine to form a (an) _____.
7. Iron and oxygen combine to form rust, or _____.
8. Water is a (an) _____.
9. Water is made up of two parts _____ and one part _____.

B. Look at each picture. Then answer the questions.

10. Tell how you can separate the objects in the picture.
11. Tell what happens to the water.



3

Matter You Breathe and Drink

Air is a gas. Water is a liquid. Air is a mixture. Water is a compound. Without air and water there would be no life on the Earth. You know you breathe air. But can you see it?

Most of the time, you can not see air. Air is invisible. Being invisible is a property of air. If air is invisible, how do you know it's there?

A

The Matter You Breathe

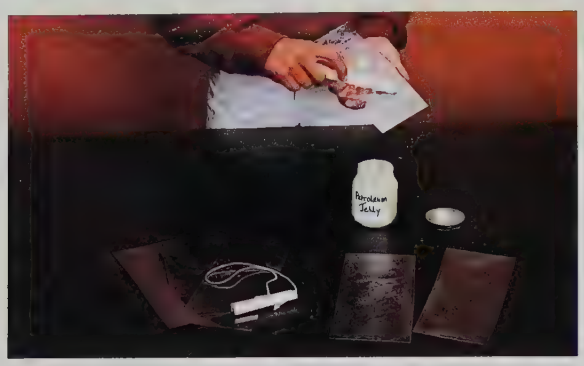
You know empty bottles aren't really empty. They are filled with air. Surely you have felt a breeze. What was the breeze made of? You have **evidence** that there is air around you.

evidence (e'vəd·ens)

You know air is a mixture of gases. Perhaps there are also solids in air. Let's try to find out.

Finding Out:

Are there solids in air?

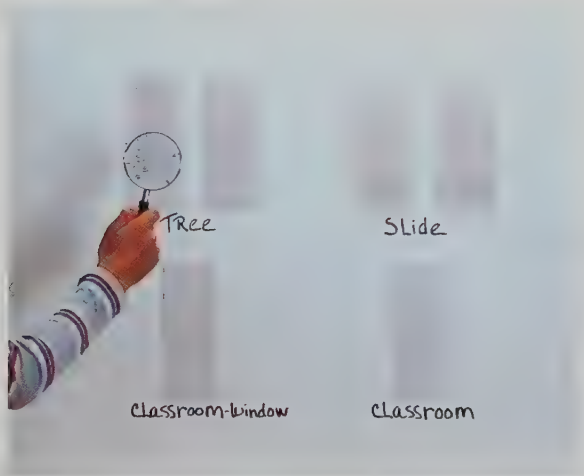


Make six plastic strips. Use six pieces of clear plastic, all the same size. Spread a thin coat of petroleum jelly on one side of each piece.

Get six clothespins. Tie a string around each one. Clip each clothespin to a plastic strip.

Then hang two strips inside your classroom. Hang one near an open window. Hang one on the other side of the room.

Hang two strips in your school yard. Be sure your teacher is with you. Perhaps you can put the strips up in a tree. Where might you hang the last two strips?



After one or two days, collect all your strips. Turn the coated sides up. Then put the strips on white paper. Observe the strips through a magnifying glass. What do you see?

What evidence do you have that there are solids in air?

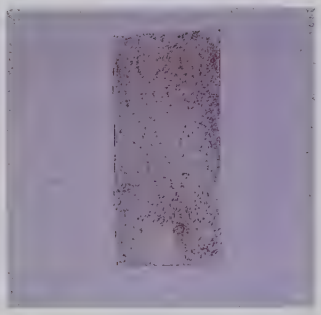
In 1776, most people burned wood in fireplaces to heat their homes and cook their food. The air indoors was often smoky. What was the smoke made of?

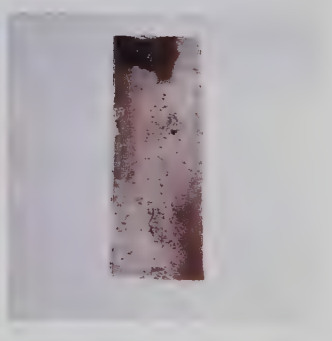
If you had lived in 1776, you might have used a greasy piece of paper instead of a coated plastic strip. If you had hung the strip inside for a day or two, it might have looked like this.

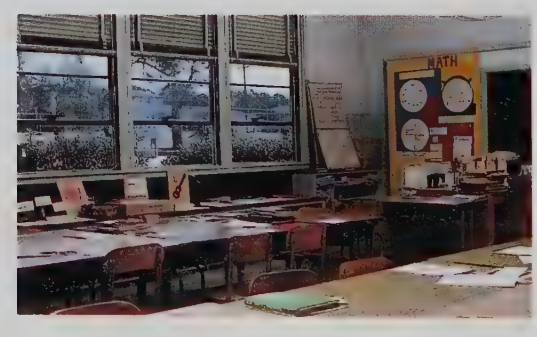
Outdoors, the air people breathed was fairly clean. But indoors, the air was full of bits of solid matter. We say the air was **polluted.** Bits of ash and black carbon from the burning wood polluted the air.

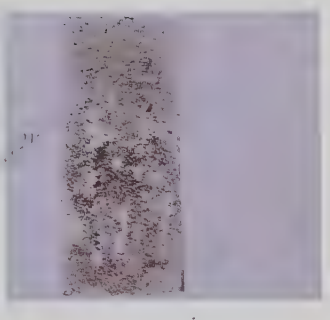
Often, in cities, people built homes close together. They still burned wood in fireplaces. Smoke poured from the chimneys. It often filled the streets. The smoke began to pollute the air outdoors.

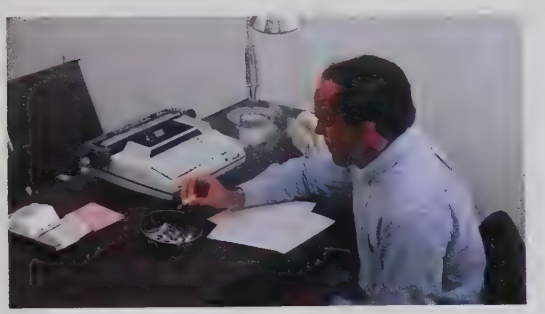
Is the air you breathe today polluted? We hung several coated plastic strips in different places. Here's how they looked after two days:











Compare the strips. Find where the air was the cleanest. Find where the air was polluted. Is the air in your environment fit to breathe? What is your conclusion?

What does the word conclusion mean?

1. Air is an invisible mixture. How do you know air is around you?
2. What evidence did you find that air has solids in it?
3. Was the air more polluted on the busy city street or on the hill in the country? Why?

Things You Know

Finding Out in the Library: Air Pollution

When you need answers to questions, the library is a good place to start.

- What are the main causes of air pollution in the environment?
- What harm can polluted air do?

The Matter You Drink

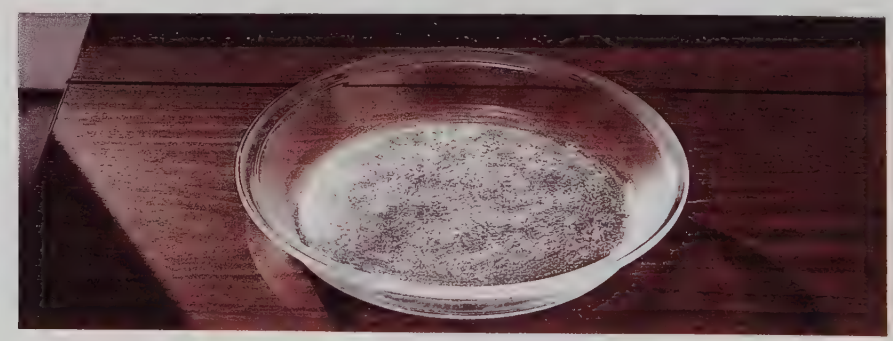
You saw that the air you breathe may have solids in it. Wind may stir up dust and bits of soil. The air may be polluted with smoke and ash. But consider the water you drink. You know the water is safe to drink. But there are solids in it.

Pour some tap water into a flat pan. Put the pan in a warm place. Observe what happens to the water.

evaporate (i·vap′ə·rāt)

The water becomes water vapor. It goes into the air. We say the water **evaporates.** After a day or so, all the water in the pan evaporates.

Here's what one girl saw in the bottom of her pan. Do you see solids in your pan?



The solids are **minerals.** Of course, the minerals were in the water all the time. But you couldn't see them before. We say the minerals were **dissolved** in the water. Weren't minerals dissolved in the water you used?

mineral (min'rəl)

dissolve (diz·alv')

Scrape off some of the minerals with a spoon. Suppose you stir the minerals into a glass of water. Predict if the minerals will dissolve. Then try it. Were you right?

You can't see the solids in the water you drink. Yet you have evidence that solids are there. Perhaps there are other things in water as well. Other things too small to see.

Water–Then and Now

Early American settlers depended on rain for their water. As rain ran downhill, it filled streams, ponds, and lakes. People caught the rain in big barrels. Rain trickled down through underground rocks and filled wells. Most of this water was clean and safe to drink. But sometimes it made people sick. No one knew why.

Many years later, scientists discovered tiny, tiny living things in water. They called these tiny things **bacteria.** Scientists learned that some bacteria make people sick. That is, some bacteria cause **disease.** Sometimes there were disease bacteria in the water people drank.

bacteria (bak·tir′ē·ə)

Today we still depend on rain for the water we drink. But in most homes, we get water from the tap. Our water is made clean and safe before it reaches us. We say the water is **purified.** Purified water does not carry disease bacteria.

purify (pür′ə·fī)

Finding Out:

How is water purified for drinking?

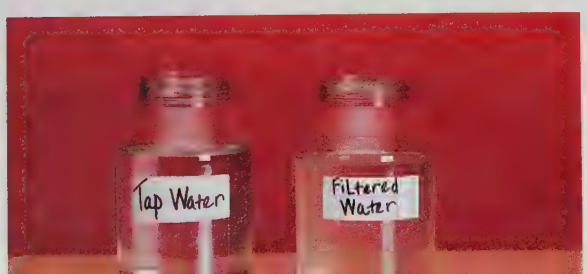
Fill a jar with tap water. Fill another jar with muddy water. Stir the water in each jar. Then let the jars stand.

Observe that the tap water doesn't change. What happens to the muddy water? Bits of soil go to the bottom. We call this settling. Settling helps make our water clean.

Now fit a paper filter into a funnel. Pour some sand into the filter. Then put the funnel into a clean jar.

Slowly and carefully, pour the muddy water into the funnel. Observe the water that drips through. How does filtering help to purify water?

Compare the filtered water with the tap water. Is the filtered water as clear and clean as the tap water? If not, explain the difference.



A Visit to a Purifying Plant

You just learned two ways that help make water fit to drink. Now let's visit a water purifying plant. Here water is purified for millions of people to drink.

First we come to the huge settling tanks. Here, as in your jar, solid matter slowly settles to the bottom. Special substances are added to make the smaller bits of matter clump together. One such substance is called alum. Adding alum helps speed up the settling.

Next, the water is filtered. It passes through layers of rocks and sand. Soil and other solid bits of matter are filtered out. Minerals, which may be dissolved in the water, stay in the water that passes through.

There may also be some disease bacteria in the water. So the water is sprayed high into the air. The air and light kill most of the bacteria. The air also dissolves in the water. It makes the water taste better.

A very small amount of chlorine gas may be added to the water. The element chlorine will kill any disease bacteria that are left.

Finally, the water is tested. This worker makes sure it is safe and fit to drink.

Perhaps you can visit a water purifying plant in your city or a city near you. It's good to know how so many people can work together to help keep you healthy.

Things You Know

1. If tap water in a pan evaporates, what is left in the pan?
2. Water in a well may have minerals and bacteria in it. Why can't you see them?
3. Why is each of these done at a water purifying plant: *settling, filtering, spraying water into the air, adding chlorine gas?*

Chapter 3

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. One property of air is that it is (visible, invisible).
2. A breeze is evidence that (air, empty space) is around us.
3. When water goes into the air, the water (settles, evaporates).
4. Some of the solids in water are (minerals, chlorines).
5. The water we drink has solids (evaporated, dissolved) in it.
6. The water we drink has no (minerals, disease bacteria) in it.
7. For all the water we drink, we depend on (rain, muddy water).
8. Smoke from burning wood pollutes the air with bits of ash and (carbon, plastic).

B. Answer each question.

9. Suppose you visit a water purifying plant. What five things are being done to the water? Tell how each thing helps to purify the water.
10. What evidence do you have that the air in the picture is polluted?

4

The Matter in Soil

Soil makes a fine home for an earthworm! Soil supplies the food and water an earthworm needs. So to an earthworm, the matter in soil is very important. Would you agree that the matter in soil is also important to you?

A

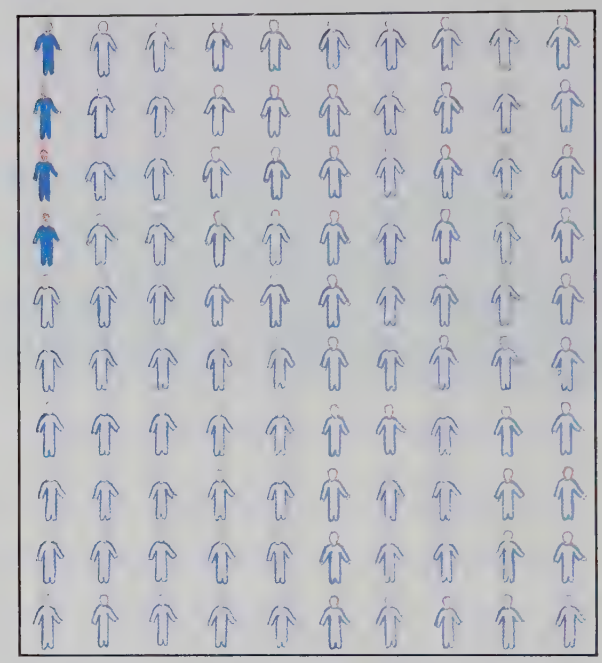
Changes in Farming

In 1776, one farm could grow enough food for one family. In a very good year, a farmer might grow enough food to feed his family and a few other people as well. Today, one farm produces much more food than one family can use.

A farmer can now grow enough food for his family and about 75 more people. What a great change has taken place!

Look at the two picture graphs. Each picture graph shows 100 people. Each 🧍 stands for one farmer. Look at the graph for 1776. More than 90 out of every 100 people were farmers. Today, 4 out of every 100 people are farmers.What are some reasons for such a great change over the past 200 years?

1776



Today

In one way, the farmers of today are much like the farmers in 1776. They use the land. They use the soil. They know soil is one of our greatest treasures. In another way, the farmers of today are different. Farmers today can grow more food than the farmers of 1776. Why?

An early American farmer may have had a horse or other large animal to help on the farm. But most work was done by hand. The whole family worked to grow the many things they needed for food and for making clothing.

Work On a Farm—Then and Now

Here are two farmers at work. Both make the land ready for planting. But one farmer's work is easier. One farmer can do more work in one day. Why?

Today's farmers use great farm machines to do most of the hard work. Today's farmers go to special schools. There they study about the land and soil. They learn about the best seeds to plant. And they learn how to care for the soil.

Why is soil so important to the farmer? Turn the page, and let's see why.

Things You Know

1. A farmer today can do more work in one day than a farmer in 1776. Why?
2. Today a farmer can grow enough food for his family and about 75 other people. Why?
3. Look at the two picture graphs on page 44. From the graphs, tell what has happened in the past 200 years.

Treasure in the Land

We need good, rich soil to grow the plants we eat. It also takes good soil to grow trees.

Not many kinds of plants grow in dry desert sand. There's not enough water for trees or most plants and flowers.

Maybe you have tried to grow seeds in sand. Did they grow well? One class tried to grow seeds in sand and in soil. Perhaps your class may want to try it too. Then you can compare your results with theirs.

The class soaked some radish seeds in water overnight. The next day, they planted the radish seeds. They put half the seeds in a pot of clean sand. They put the other half in a pot of garden soil. They labeled each pot and wrote down the date.

Then they put both pots in good light. They watered each one. They kept the sand and soil damp, but not muddy. They observed the pots every day.

After about a week, they saw the first green sprouts. They made notes about the new plants as the plants grew. In time, here's what they saw.

How long did it take your plants to grow like those at the right? Describe any differences you observed. Suppose you got the same results. If so, you have *confirmed* the work the other class did.

Finding Out:

Are sand and soil alike?

Get some dry sand, some dry garden soil, and two sheets of smooth paper. Spread some sand on one sheet of paper. Spread some soil on the other.

Observe the grains of sand with a magnifying glass. Describe what you see. Feel the grains of sand with your fingers. Describe how they feel. Sniff the sand. Does it have an odor?

Study the soil, bit by bit. Use the magnifying glass. Look for bits of matter other than sand. Do you see anything that wiggles, crawls, or moves around? Look for bits of dead plant matter. Perhaps you see pieces of leaves and stems. Or you may find some seeds.

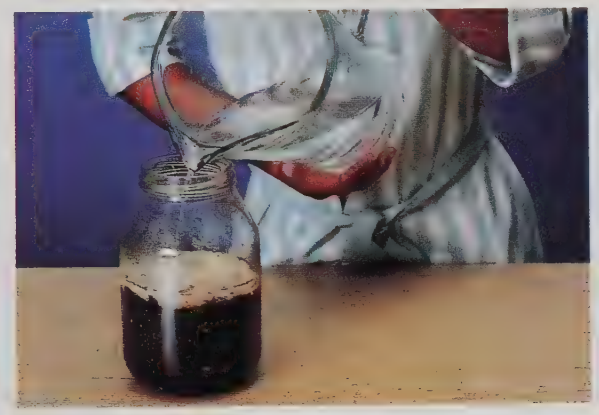
Rub some soil between your fingers. Are there tiny bits of rocks in your soil? Sniff the soil. How does it smell?

How are sand and soil alike? How are they different? Share your observations with your class.

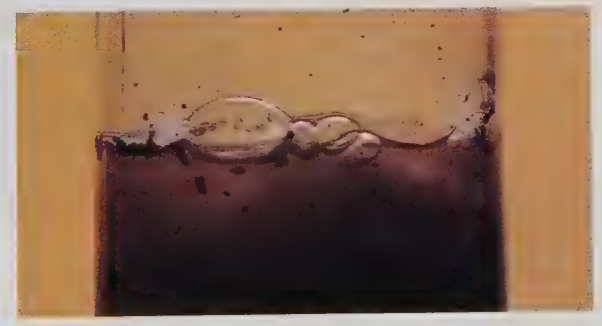
Fill a jar halfway with good soil. Cover the jar with a lid. Let the jar stand in a warm place overnight. Observe the inside of the jar the next day.

Open the jar. Find the liquid on the inside of the lid. Is the liquid water?

Get some distilled water. Distilled water is water without any minerals dissolved in it. Put a piece of wet paper towel on top of the soil. Slowly pour the distilled water on top of the paper. Keep pouring until your jar is almost full.



Watch carefully. You'll see bubbles coming from the soil. What are the bubbles made of? What's your best guess?



Suppose you filter some soil water. Then pour some of the filtered water into a dish. When all the water evaporates, you see solids in the dish. What do you think the solids are?

The Matter in Soil

Sand is mostly tiny bits of broken rock. You now have evidence that soil is different. Soil is a mixture of three kinds of matter.

- You saw bubbles of gas come up from the soil. That gas was air.
- You saw droplets of liquid inside your jar. That liquid was water.
- You also saw bits of solid matter in soil. Those solids were bits of dead plants, animals, and rocks. And you saw that minerals from soil were dissolved in soil water. Plants need these minerals to grow.

So soil is made up of gases, liquids, and solids. Yet it looks solid.

Things You Know

1. How are sand and soil alike? How are they different?
2. What differences did you observe when you grew radish seeds in sand and in soil?
3. Soil has air and water in it. How can you show each one is in soil?

Using What You Know

Write the answers to all questions in your science notebook.

A. Read each sentence. Use terms from the list below to fill in the blank spaces. You may use a term more than once.

air, animals, desert, farmers, machines, minerals, mixture, sand, soil, soldiers, water, 4, 10, 75

1. An earthworm gets its food from the _____.
2. About 200 years ago, 90 out of every 100 people were _____.
3. Today a farmer can grow enough food for his family and about _____ more people.
4. Today farmers do most of their hard work with _____.
5. To grow the plants we eat, we need good _____.
6. There is not enough water for most plants to grow in the _____.
7. Radish plants grow better in _____ than in sand.
8. Soil water has _____ dissolved in it.
9. Soil is a (an) _____.

B. Look at the pictures below. Then answer questions 10 and 11.

10. In which picture do you see sand? Explain why.
11. In which picture do you see soil? Explain why.

a.

b.

Science and Technology:

Oxygen Saves Lives

You are about to learn the use of a new and important word. The word is **technology.** Technology is not new to you. An automobile is a fine piece of technology. So is a bicycle. So is a camera. Technology is part of your life.

Perhaps you have heard the word technology used together with the word science. You know that all matter is made up of atoms. Air, for example, is made up of different kinds of atoms. Scientists discovered that the atoms we use in the air we breathe are oxygen atoms.

In time, we learned how to separate oxygen from the other atoms in air. We learned how to put oxygen into tanks. Now we use oxygen to save people who have taken in too much smoke during a fire. We also use oxygen to save people with diseases of the lungs and heart. Many discoveries have made this possible.

All the uses of oxygen are part of technology. Technology uses the discoveries of science. Technology and science go hand in hand.

Suppose you wanted to tell others what you have learned from this unit. What would you write? Perhaps this.

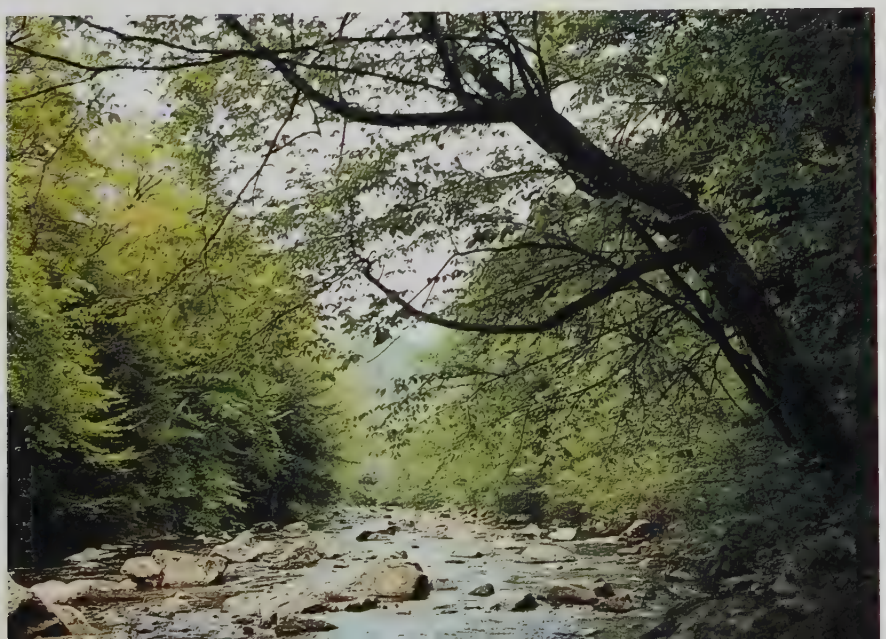
All things around us are made up of matter. Matter is anything that takes up space and has weight. A ball is made up of matter. So is a skate. So is food.

Matter may be a solid, like a rock. Matter may be a liquid, like water. Or matter may be a gas, like the oxygen in air.

Solids, liquids, and gases are states of matter. Matter can change its state. For example, solids can change to liquids. Liquids can change to gases.

All matter is made up of atoms. An element, such as iron, is made up of only one kind of atom. Copper, aluminum, and oxygen are also elements. Elements can combine to form compounds. Rust is a compound. Rust is made up of iron and oxygen.

Also we can break down compounds into elements. Water is a compound. What two elements is water made of?



Unit 1

You Know A Great Deal

Write the answers to all questions in your science notebook.

A. Choose the term that makes each sentence correct. Then write the letter of the term you choose.

1. We classify air as
   a. a compound **b.** an element **c.** a mixture
2. Matter that spreads to fill whatever it's in is a
   a. liquid **b.** gas **c.** solid
3. A change of state takes place when
   a. ice melts **b.** steel wool rusts **c.** rocks break
4. Aluminum, carbon, and oxygen are
   a. compounds **b.** vapor **c.** elements
5. About four parts out of five parts of the air are
   a. oxygen **b.** hydrogen **c.** nitrogen
6. When we purify the water we drink, we do *not* remove the
   a. solids **b.** minerals **c.** disease bacteria
7. Electricity can be used to break down water into
   a. hydrogen and oxygen **b.** oxygen and carbon **c.** hydrogen and carbon
8. Anything that has weight and takes up space is
   a. a property **b.** matter **c.** an environment
9. We do *not* pollute the air when we add
   a. water **b.** smoke **c.** dust
10. When water in a dish changes to water vapor, the water
    a. dissolves **b.** evaporates **c.** settles

B. Answer each question.

11. Why is soil known as one of our greatest treasures?
12. How are farms today different from those in 1776?

A Skill of the Scientist: Classifying Matter

You can classify the matter in your environment into three kinds. Is the matter you choose a solid, a liquid, or a gas?

Classify at least 10 things in your environment. Describe some of the properties of the matter you choose. You may want to make a chart like this one. Here are two examples to start you off:

Thing	Kind of Matter	Properties
new penny	**solid**	**hard, copper color, shiny**
water	**liquid**	**wet, no color**

Do you see how properties help tell what kind of matter it is?

Books For You:

Chemistry, by Derek Walters, published by Watts, New York, 1982. To explore important ideas about chemistry, including atoms and molecules, read this book.

Farm Giants, by Ross Olney, published by Atheneum, New York, 1982. This book describes farm machines from the simple to the very large.

Air, by David Lloyd, published by Dial Press, New York, 1983. Using pictures, this book shows that air can be very gentle or can blow with great force. A sky diver can fall slowly through the air. Or air can destroy a town.

The Matter We Use

When you are home, look around you. What things do you find that *you* grew from seeds? Do you find things that *you* dug from the land? What do you find that *you* made yourself?

Suppose you removed from the room all the things other people have made. What would you have left?

We make very few of the things we use, we wear, or we eat. Most of us don't grow our own

Unit 2

food. The oil or coal we may use for heating is brought from far away. Our clothes come from plants, such as cotton. Or our clothes come from animals, such as sheep. People use machines to make cloth from the wool and the cotton.

Oil and coal come from the Earth. So does the food we eat, the water we drink, and the air we breathe. All the matter we use comes from the Earth.

Surely, we depend on the Earth to stay alive. Do you agree?

5

The Matter You Wear

What are you wearing today? Think about where the cloth to make your clothes came from. The cloth may have come from plants or animals. Perhaps the cloth came from a test tube.

A

From Fibers and Skins

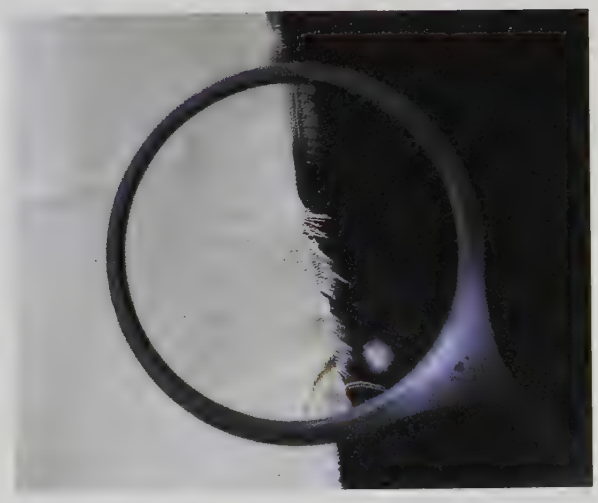
Most people who came to America 200 years ago grew their own food. Many of them made most of their own clothing. At first, most cloth was made of linen or wool. Skins of animals were also used. Some families made cloth from the cotton they grew.

The clothes people wore had one thing in common. The cloth and skins they used for clothes came from animals and plants. We say the cloth was made from *natural fibers.* Natural fibers come from living things.

Today we still make some cloth from natural fibers. We still use linen, cotton, and wool to make clothes. Silk is another natural fiber. Most of our silk comes from other lands.

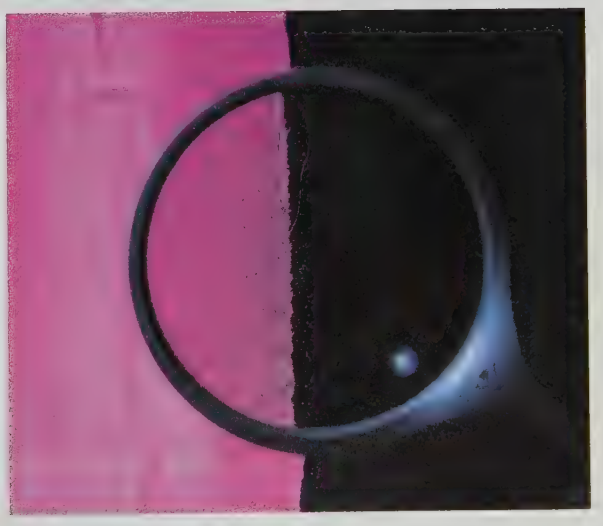
See if you can get pieces of linen or cotton. You may also be able to get wool and silk cloth. Perhaps you can use a pin to pull a few threads from each piece. Study the threads with a magnifying glass.

Linen



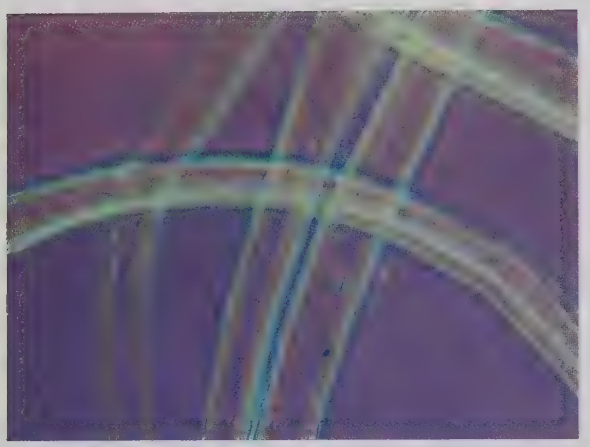
Cotton

Wool

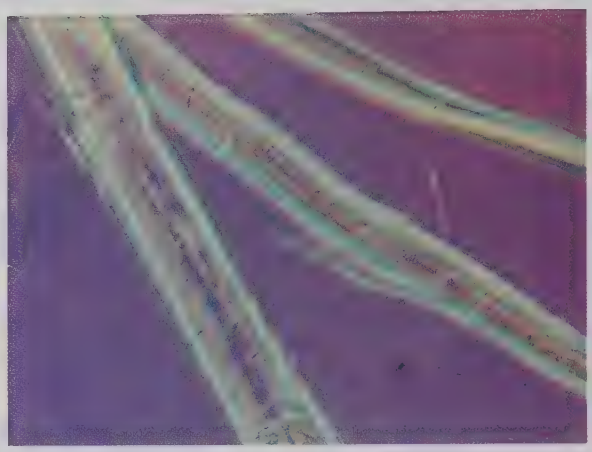


Silk

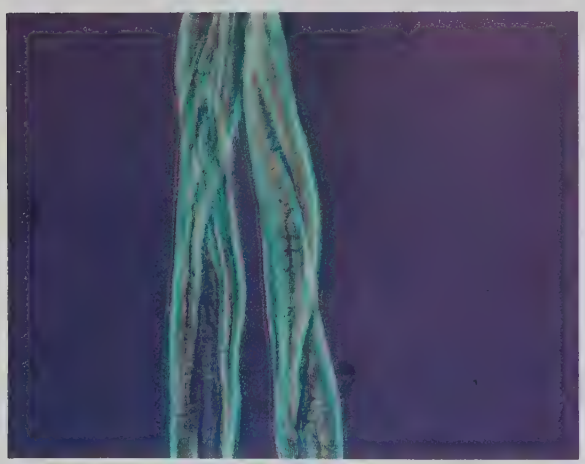
These pictures show fibers seen through a microscope. See how wool is different from the other fibers. Find how cotton and linen fibers are alike. Compare silk with the other fibers. What do you observe?



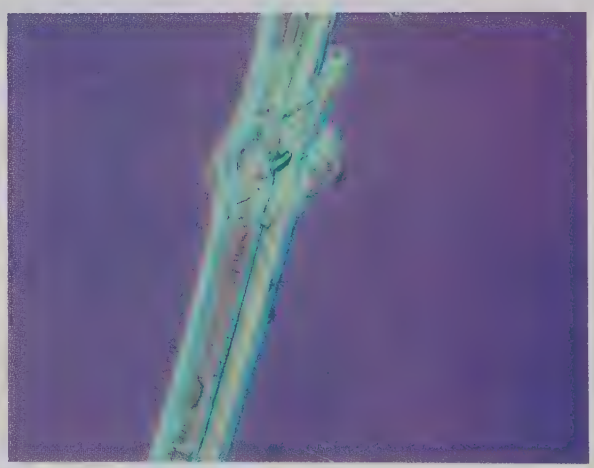
Wool



Linen



Cotton



Silk

Things You Know

1. What do we mean by a natural fiber?
2. Name four kinds of natural fibers.
3. Suppose you looked at fibers with a magnifying glass. How is wool different from linen or cotton?

These flax plants are in bloom. The stems of flax plants are strong and stringy. First, the flax fibers must be separated from the stems. Then the fibers can be used to make linen.

The fluffy, white puffs on these plants are cotton bolls. These bolls are ripe and ready for picking. Inside the bolls are the seeds. First, the soft fibers must be separated from the seeds. Then the fibers can be made into thread.

Sheep's wool is something like curly hair. First, the wool is cleaned. The fibers are straightened. Then the fibers can be spun into yarn. After the wool is removed from the sheep, the wool grows back.

A silkworm is an insect. It wraps itself in a cocoon. The cocoon is made of one very, very long fiber. First, the fiber must be pulled into a long thread. Then it can be spun into silk.

You know that fibers are made into cloth. The cloth is used to make clothes and other things. Let's see how fibers were made into thread in early America. Then compare this way with how it is done today.

From Fibers to Cloth – Then and Now

The early settlers made cloth by hand. They used tools to separate fibers from flax stems. They used tools to comb and clean wool from sheep.

In 1793, the cotton gin was invented. The cotton gin was a new technology. It was used to pull cotton fibers from cotton seeds.

A spinning wheel was used to twist the fibers into thread. The thread was then made into cloth. A machine called a loom was used.

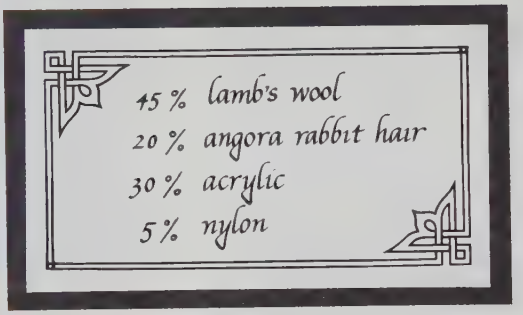
Today, hand tools are no longer needed. Machines make cloth faster and easier. Today's machines are not run by hand. They are run by electricity. Electricity, you know, also lights your home.

Things You Know

1. What plant or animal is each of these made from: linen, wool, silk?
2. Tell how cotton cloth was made in early America. Start with a cotton boll.
3. Why is it easier to make cloth today than it was in early America?

Fibers in a Test Tube

This sweater looks as if it were made of wool. But let's look more closely at the label. The sweater is not made of wool only. The sweater is made of different kinds of fibers.

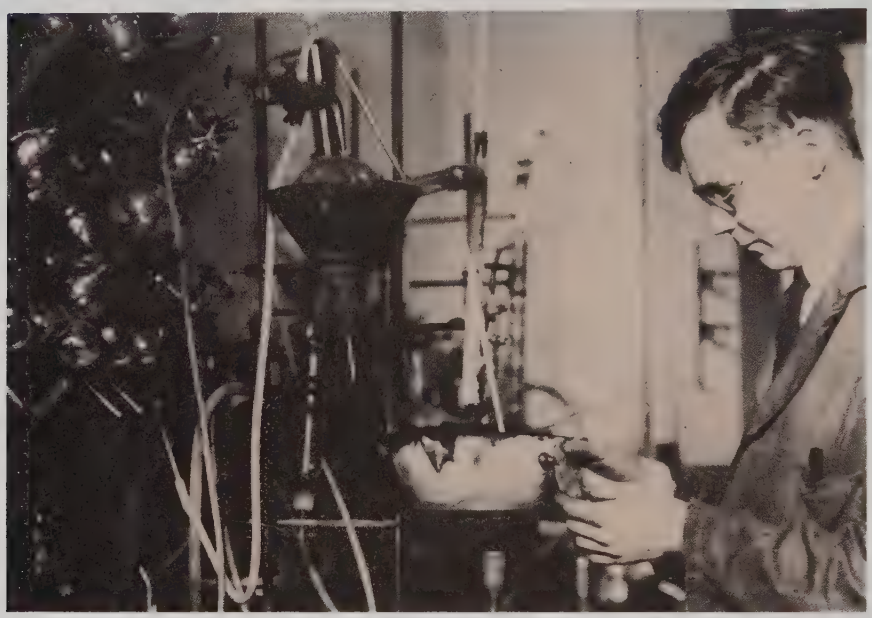


Some of the fibers are natural fibers. What plants or animals did the natural fibers come from? Nylon and acrylic are not natural fibers.

Today, much of our clothing, bedding, and carpeting are not made from natural fibers. Today we use fibers that did not come from living things. Many of today's fibers are made in a laboratory. These fibers are made from the elements found in air or water. Some of the elements are found in coal and oil.

One Fiber in a Test Tube

Chemists are scientists that study elements and compounds. They study how elements are made into compounds. More than 60 years ago, Wallace Carothers was working with a team of chemists. They were trying to make new fibers in the laboratory.



They tried to combine four elements to make a new fiber. The elements were carbon, oxygen, hydrogen, and nitrogen. After many years, they made a new compound. The new compound formed a long, fine fiber when it cooled. The fiber was strong and stretched easily. It was very much like the fibers from silk or wool.

Carothers and his staff of chemists had made nylon. And what a wonderful discovery it was! Like natural fibers, nylon can be spun and dyed. It can be woven and knitted. It is easy to wash. And it dries quickly.

Nylon was one of our first *laboratory fibers.* It was a new technology. Since then, chemists have produced many more laboratory fibers and materials.

Bring some pieces of different kinds of cloth to class. Perhaps you can use cotton, linen, wool, silk, and nylon. A square piece about the size of a stamp would be fine.

Perhaps your teacher will hold each sample in a flame. Watch from a safe distance. Observe the color of the flame. Sniff the air.

Which fibers burn? Do any of the fibers melt? Some fibers smell like burned paper. Other fibers smell like burned hair.

After each sample burns, your teacher may put it in a pan. Examine the burned sample and the ashes that are left. How would you describe the ashes? Record your observations in your notebook. You can use a chart like this one.

Are all fibers alike? Why do you say so?

Fiber	Burns or melts	Color of flame	Smells like	What are the ashes like?
Cotton	burns	yellow	burned paper	gray; feathery
Linen				
Wool				
Silk				
Nylon				

Predict what will happen when a piece of acrylic cloth burns. Were you right?

Leather and Rubber

You know that you walk on the heels and soles of your shoes. The top parts of your shoes are the uppers. What materials are the different parts of your shoes made of?

Natural leather comes from the hides of cows and other animals. In early America, most boots and shoes were made of leather. Today we still use leather in making some boots and shoes. We also use other materials.

Now scientists know how to make leather in the laboratory. This leather looks and feels like natural leather. Look at the soles on the shoes you are wearing. Look at the heels and the uppers too. Are any parts of your shoes made of natural leather? How can you tell?

The heels or soles of your shoes may be made of rubber. Natural rubber comes from trees. But rubber can also be made in the laboratory. In some ways, laboratory rubber is better and stronger than natural rubber.

Things You Know

1. Where do natural leather and natural rubber come from?
2. From what are nylon fibers made? Why is nylon a useful fiber?
3. Look at the labels in three things you like to wear. Which of the fibers were made in the laboratory?

Chapter 5

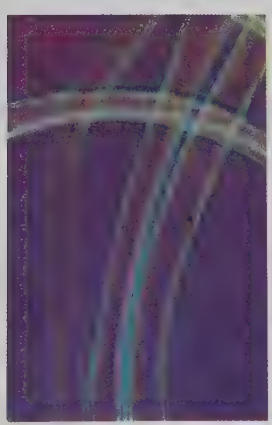
Using What You Know

A. Read the sentences below. One of the underlined terms below makes the sentence correct. Write the correct term in your science notebook.

1. A fiber made in a test tube is (silk, nylon).
2. A natural fiber that comes from an animal is (cotton, wool).
3. Fibers are made in the laboratory from elements in air and (acrylic, coal).
4. Natural leather comes from (animal hides, trees).
5. Fibers from flax plants are made into (cotton, linen).
6. The fibers from an insect's cocoon are spun into (silk, cotton).
7. When cotton fibers are burned, the ashes are (gray and feathery, yellow and thick).
8. Chemists study how elements are made into (electricity, compounds).

B. Answer each question.

9. Describe how cotton cloth is made today.
10. Here are four fibers seen through a microscope. Which is wool? Which is silk?



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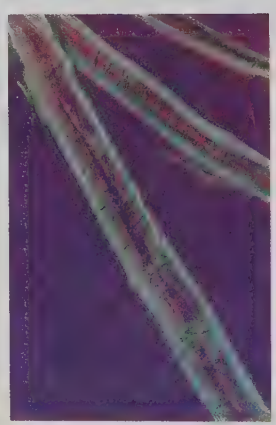

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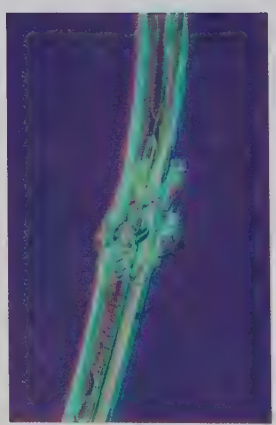
c.



d.

6

Mining the Land

Look at both pictures on this page. Do the pictures show pieces of rock or wood? Were they made in a laboratory? No, both pictures show pieces of coal. Observe that one piece of coal has a print of something in it. What is it? How did it get there? To answer these questions we need to know more about coal.

A

Matter That Burns: Coal

You may know that coal is a **fuel**. It burns. When a fuel burns, it gives off heat. For hundreds of years, people have used coal for heating homes and cooking food. Today coal is used mainly to make electricity.

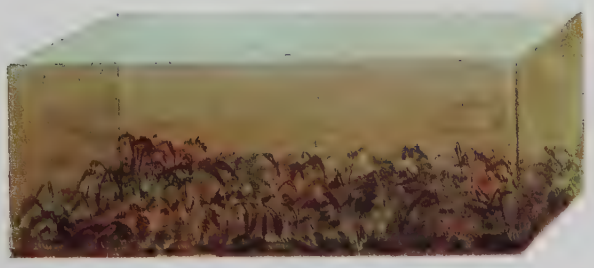
Coal comes from the ground. It is mined in many of our states. Let's find out how coal began.

How Coal Began

Let's go back millions and millions of years ago. Let's go back long before people lived on the Earth. We are back in a time we now call the Coal Age. Here we are at a Coal Age swamp. The air is hot and heavy with moisture. Many strange plants grow around the edge of the swamp. Look at the giant tree ferns! Look at the other plants and trees. They are so different from plants today.

Coal did not grow. But it was made from things that did. When trees and other plants died, they fell. Often they fell into the muddy swamp.

Tree ferns and other plants died and fell. They formed a layer of dead plants on the muddy bottom of the swamp.



Mud and some sand slowly settled on top of the plants. A muddy layer now covered the layer of dead plants.

Layer on top of layer formed, as more plants fell into the swamp. More mud sank down to cover the dead plants. Over thousands and thousands of years, many layers of mud and dead plants were formed.

The weight of the layers pressed down on the plants. The weight grew heavier and heavier as more layers were formed. The layers pressed down on each other. The layers became hot. There was very little air. Slowly, slowly, the layers changed.

The layers of mud changed to rock. The layers of dead plants changed to coal.

The Black Element in Coal

You know coal is made mainly of carbon. Where does the carbon in coal come from? Let's see.

People once burned wood from trees in ovens like these. Inside the ovens there was very little air. As the wood was heated, it began to change.

Here's what the wood looked like when it came out of the oven. Does it still look like wood, or does it remind you of something else?

When wood is heated where there is very little air, the wood becomes black. It turns to charcoal. Charcoal is made of carbon. Carbon is black, and it can burn.

The carbon in charcoal came from trees. The carbon in coal came from trees and other plants that changed into coal.

Prints in Coal

These pieces of coal have prints of leaves in them. Prints like these are called **fossils.** These fossils are prints of plants that lived a very long time ago.

These fossils are evidence that coal was formed from plants. Why do we say so?

fossil (fäs'əl)

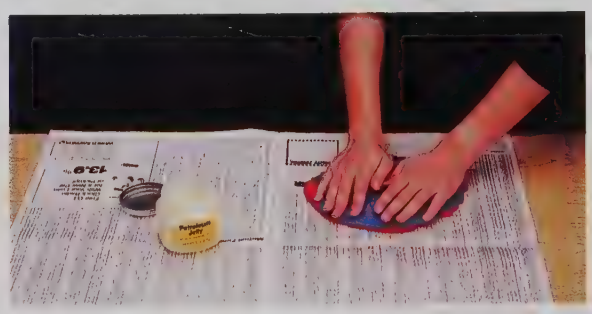
Finding Out:

How are fossil prints made?

Bring two or three different kinds of leaves to class. Place a sheet of newspaper on a table. Make two layers of modeling clay. Make each layer about one centimeter deep.

Spread both sides of your leaves with a thin coat of petroleum jelly. Press the leaves into one layer of clay.

Cover the leaves with the other layer of clay. Press it down firmly, but not too hard.



Now lift the top layer of clay and turn it over. Do you see any prints?

Carefully lift the leaves from the bottom layer. How do these prints compare with the prints in the top layer?

1. Describe how trees in a Coal Age swamp changed into coal.
2. How are coal and charcoal alike? How are they different?
3. How are fossil prints in coal evidence that coal was formed from plants?

A Project: Hunting Fossils

Not all fossils are found in coal. Some fossils are found in rocks that were once layers of mud or sand. Prints of plants are often found in these rock layers. Sometimes, even bones of dinosaurs are found.

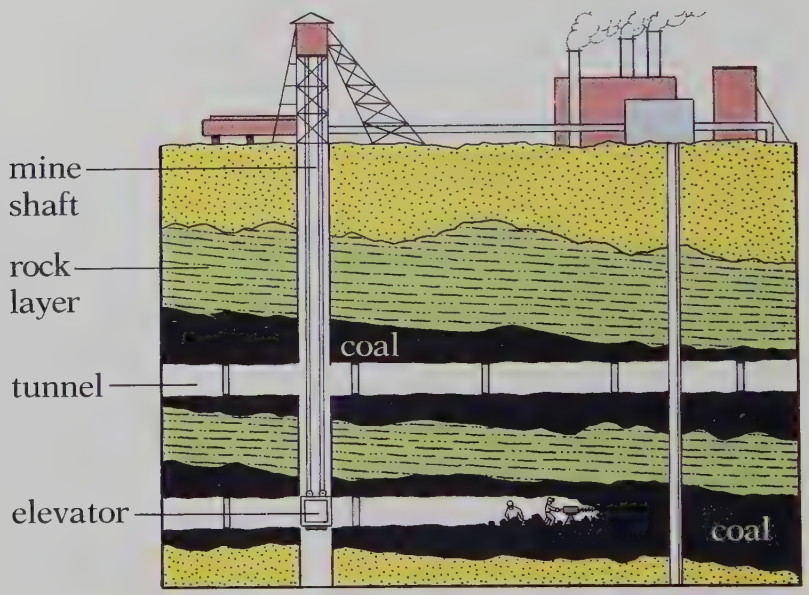
Prints of shells and of fish may be found in layers of rock that were formed under water. Here is a print of a fish that lived on the Earth millions of years ago.

Perhaps you live near a place where a road is being built through layers of rock. There may be fossils in these layers. With the help of an adult, you may be able to go fossil hunting. What kinds of fossils might you find? How can you collect and observe them? The book, *If You Are a Hunter of Fossils,* by Byrd Baylor and Peter Parnell, published by Scribner, New York, 1980, may aid you in your search.

B

Coal from the Ground

You know layers of coal were formed between layers of rock. Sometimes the layers are deep underground. Miners dig a hole, or mine shaft, to get to the coal. An elevator is used to go up and down the shaft. At each coal layer, tunnels are made. Miners pick, drill, and blast to break up the coal.



The miners load the coal onto mine cars. The elevator lifts the coal up to the surface. Trucks carry the coal away.

Coal Near the Surface

Suppose the coal is found near the surface. Then a different kind of mining is done. Giant earthmovers clear away layers of soil and rock. Then it is easy to dig out the coal. A huge shovel scoops up the coal. Then the coal is loaded into waiting trucks.

The last of the coal has been dug from this mine. A large hole is left in the ground. The hole must be filled in with rocks and good soil. Then the land must be planted again. In this way the land is saved.

Things You Know

1. Tell how coal is mined from deep, underground layers.
2. How is coal mined when it is found near the surface?
3. What is done to save the land after the coal is dug from a surface mine?

Matter That Burns: Oil

In 1859, a man in Pennsylvania was digging a well. But he wasn't digging for water. He was excited when the well filled with a brownish-black liquid. The liquid was *petroleum.* Today we usually call petroleum by another name–oil.

This picture shows crude oil—a dark, thick liquid. Crude oil is petroleum as it comes from the ground. Petroleum, like coal, is a fuel. It burns. In fact, petroleum is one of the most important fuels we use today.

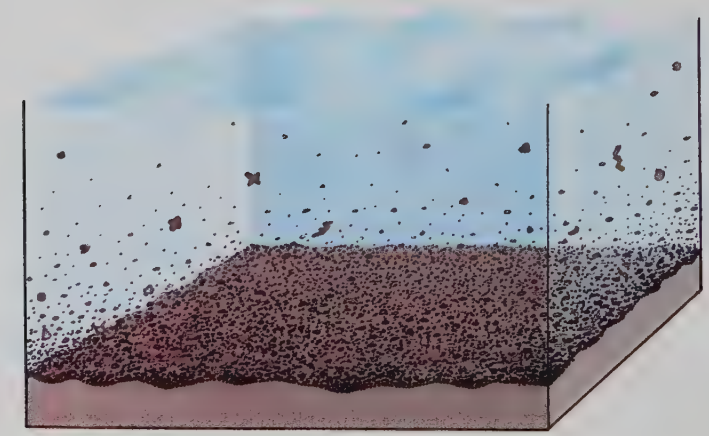
Gasoline, candle wax, and even some medicines come from petroleum. Petroleum is also used in making fibers and rubber in the laboratory. Spoons and forks may also be made from compounds found in petroleum. We say these spoons and forks are made of plastic.

Where Oil Began

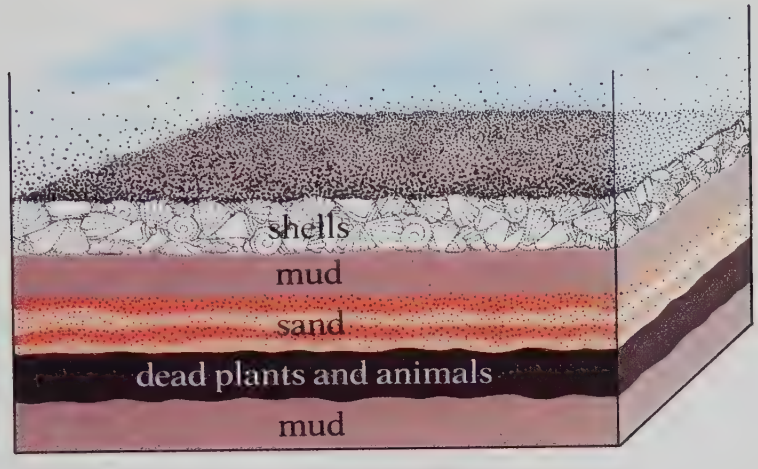
The word petroleum comes from two Latin words. *Petra* means rock, and *oleum* means oil. At first petroleum was called *rock oil.* To find out why, let's see where petroleum began.

Scientists think petroleum began millions and millions of years ago. Very tiny plants and animals lived in the oceans, as they do now. These pictures show the plants and animals many times their real size.

A long time ago, these tiny plants and animals died. They sank to the bottom of the ocean. Sand drifted down. It covered the millions of tiny dead plants and animals.



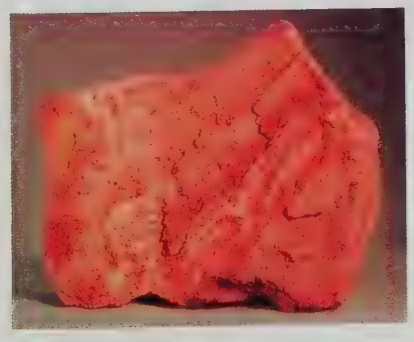
Mud drifted down and made a layer over the sand. Shells of dead sea animals sank down. The shells formed yet another layer on top of the sand and mud.



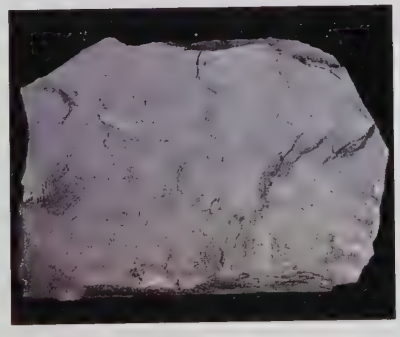
And so it went. Layer piled on top of layer. As the layers piled up, they pressed down on each other. Slowly, over millions of years, the layers changed.

The layers of shells changed to *limestone.* The layers of mud changed to *shale.* The layers of sand changed to *sandstone.* Limestone is a rock. Shale is a rock. So is sandstone.

The dead plants and animals changed too. They changed to bubbles of gas and droplets of oil.



Limestone



Shale

Sandstone

Then the Earth changed. The bottom of the sea pushed up. Some of the rock layers folded over and changed their shape. The gas and oil were trapped in the rocks.

Things You Know

1. Name five different kinds of things made from petroleum.
2. Sandstone, shale, and limestone are rocks. From what was each rock formed?
3. Describe how petroleum was formed over millions of years from tiny plants and animals.

Careers: In Using Natural Resources Wisely

All the Earth's matter–its air, water, soil, metals, and fuels–make up our natural resources. Even the plants and animals that live in the wild are part of our natural resources.

The work of many people helps us use our natural resources wisely. Some people test our air and water for pollution. Other people develop ways to keep the air clean and to get rid of wastes safely.

Mine workers may operate huge machines to dig coal or metals from the Earth. Petroleum workers also use machines to drill oil wells. But people who dig coal, mine metals, and drill oil wells try not to disturb the natural environment. Mining engineers try to find the best way to remove coal, metals, and oil from the Earth. Other engineers look for new ways to get food and to mine substances from the sea.

Forest rangers and tree planters help to protect our forests. Still other people work to protect animals that live in the wild. As you can see, there are many ways we can use our natural resources wisely.

Perhaps you can examine a piece of sandstone. Touch it with your fingers. Does it feel rough or smooth?

Look at the sandstone with a magnifying glass. Observe the grains of sand. The grains of sand were pressed together long ago when the sandstone was formed.

Suppose you drip a few drops of oil onto a clean piece of sandstone. If you try to wipe off the oil, you can't. The oil sinks into the sandstone.

This picture shows a piece of sandstone magnified many times. Between the grains are spaces called pores. Oil or gas may be stored in the pores of rocks like sandstone. We say sandstone is a *porous* rock.

Over millions of years, the Earth kept changing. Some of the seas became dry land. Today we find most petroleum in layers of porous rock. This rock was once buried under the sea. Now you see why petroleum was called rock oil.

Finding Out:

How is oil stored in porous rock?

Take a tall jar with a wide mouth. Mark off three equal layers. Use a marking pencil or some tape.

Fill the jar with coarse gravel or small pebbles. Fill it to the brim. Add a few drops of blue food coloring to a glass of water. Slowly pour enough blue water into the jar to reach the first mark.

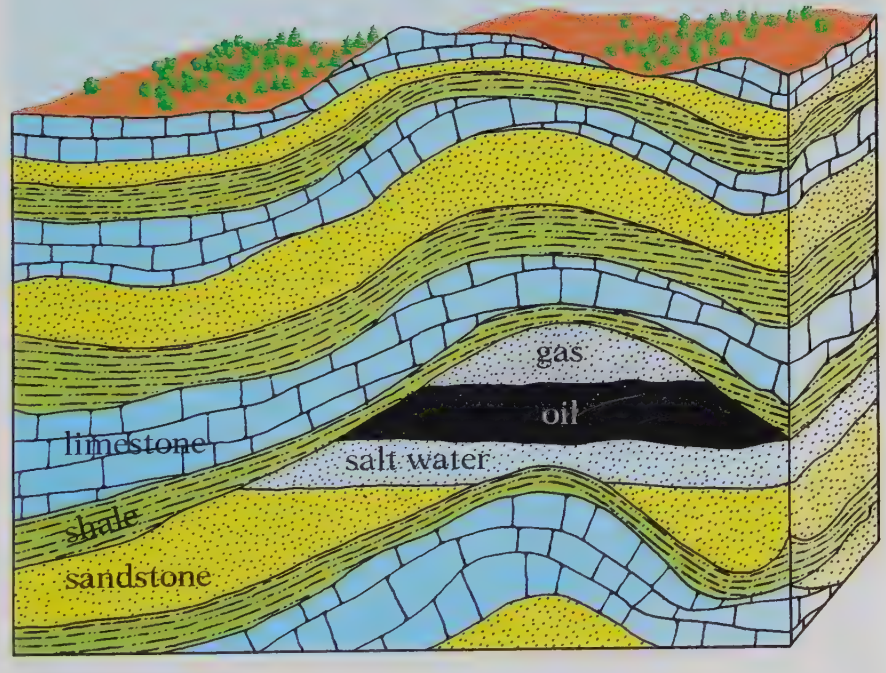
Next, pour in dark colored oil until the liquid reaches the second mark. Pour the oil slowly around the rim of the jar. Does the oil mix with the water? What does the oil do? Observe that air fills the spaces between the pebbles of the top layer.

You have made a *model* of how oil is stored in porous rock like sandstone. Scientists often make models to learn more about things.

Drilling for Oil

Look at the layers of rock in the picture. Compare these layers with the layers in the model you made. Find the layer with the oil. It is trapped below the shale. Shale is not a porous rock.

Now compare these oil layers with the layers where coal is found. How are oil layers different from coal layers?



The great steel tower is a drilling rig. A drilling rig is an important invention. It houses the machines needed to dig for oil.

First, a large drill cuts through layers of soil and rock. Next long, long pipes are forced through the soil and rock to reach the oil. Then the oil is pumped up to the surface. Trucks, railroad cars, and ships may carry the oil away.

Oil may be found in many places. Oil wells may be drilled under ground or under water. Ocean wells are drilled into rock layers deep below the ocean floor.

Things You Know

1. Today we find oil and gas in layers of rock that were once beneath the sea. Explain why.
2. Describe how oil is removed from rock layers.
3. How can you show that oil, water, and gas are found in different layers of porous rock?

Using What You Know

A. Fill in the blanks in the paragraphs about fuels.

Use the terms below to tell how coal was formed. Write the numbers 1 to 6 in your science notebook. Then write the correct term next to each number. You may use a term more than once.

carbon, charcoal, dead plants, fossils,
fuel, muddy swamps, rock

Millions of years ago trees and plants died and fell into ___(1)___. The layers of mud changed to ___(2)___. The layers of ___(3)___ changed into coal. The black element in coal is ___(4)___. Prints of plants in coal are called ___(5)___. In a coal mine, layers of coal are found between layers of ___(6)___.

Use the terms below to tell how oil was formed. Write the numbers 7 to 12 for your answers.

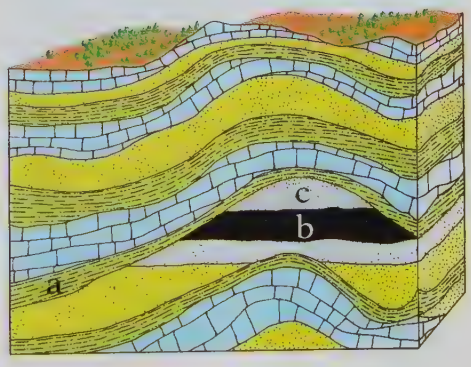
animals, gas, limestone, oceans,
sandstone, shale, wells

Oil was formed millions of years ago from tiny plants and ___(7)___ that lived in the ___(8)___. Layers of sand changed to ___(9)___. Layers of mud changed to ___(10)___. Oil is trapped in porous rock, such as sandstone and ___(11)___. The tiny living things changed to oil and ___(12)___.

B. The picture shows layers of rocks where you would drill for oil.

13. What kind of rock would you find in layer **a**? Why?

14. In which layer would you find oil? Why?



7

Mining the Sea

Look at planet Earth out in space. Observe how much of our planet is covered by water. Observe how little is land. Almost three-fourths of the Earth's surface is covered by oceans. What great treasures do these oceans hold?

A

Riches in Seawater

Maybe you live near the ocean or sea. If so you can bring some seawater to class. When you get to class, filter the seawater through some cotton. Filtering the seawater will remove tiny bits of pebbles, shells, and sand.

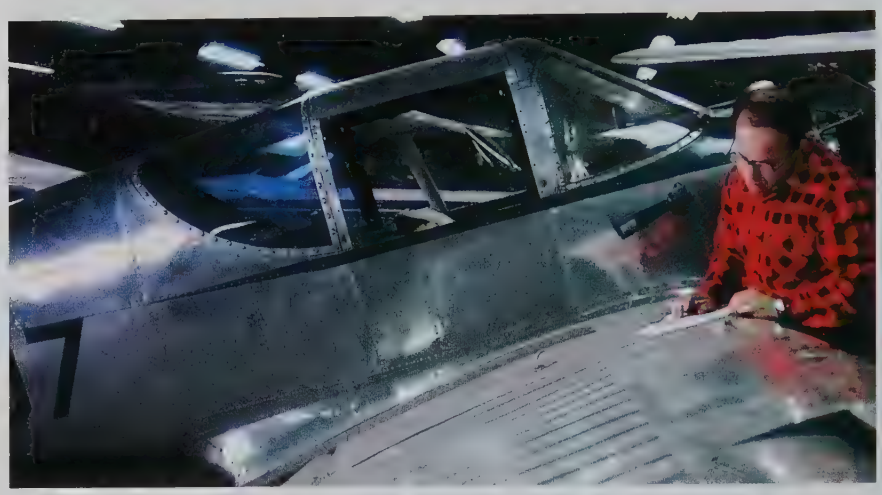
Compare a glass of seawater with a glass of tap water. Look at both glasses of water. Then smell them. Surely you can tell which glass has seawater in it.

Suppose you pour some seawater into a pan. Predict what will happen when all the water evaporates. What do you think will be left in the pan?

Like tap water and soil water, seawater has minerals dissolved in it. The chief mineral in seawater is table salt.

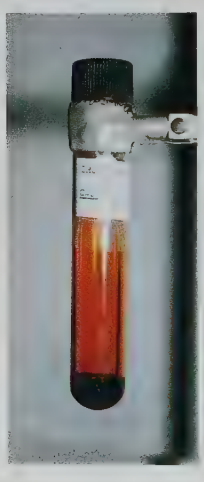
At this plant in the Canary Islands, evaporation is used to separate salt from seawater. First the seawater is trapped in shallow pools. The seawater evaporates in the sunlight. The salt is left behind.

Salt is not the only substance we find in seawater. We get magnesium from the sea. Magnesium is a metal. It is light in weight. Magnesium is often used to make some parts of airplanes.



Bromine is a dark red, liquid element. It is used in making some kinds of gasoline. Some dyes and medicines are made from compounds of bromine we get from seawater.

Have you ever had a cut treated with iodine? Iodine is a dark silvery element we get from the sea. Gold and other metals can be found in seawater too.



Growing Plants in Seawater

You know seeds need water to sprout. And sprouting seeds need water to grow. Plants need water to grow leaves, flowers, and fruits. Plants need water to keep growing well.

We don't find many farms in the desert. The desert is much too dry for plants to grow. But suppose we could bring seawater to the desert. Could we use all that water to farm desert land?

Finding Out:

Do seeds grow well in seawater?

Line four glasses with blotting paper. Mark two glasses **A.** Mark two glasses **B**.

Put 4 bean seeds in each glass. Put the seeds between the glass and the blotting paper.

Water the glasses marked **A** with tap water. Water the glasses marked **B** with seawater. If you don't live near the sea, you can get seawater at a store that sells tropical fish. Use just enough water to keep the blotting paper damp.

Which seeds sprout fastest? How many days does it take?

When the seeds have sprouted, put the small plants in the light. Keep watering the glasses marked A with tap water. Keep watering the glasses marked **B** with seawater. Which plants grow well? What makes the difference?

Most farmers don't use seawater to water crops. Why?

Separating Salt from Seawater

Food plants don't grow well in seawater. And seawater is much too salty to drink. Is there a way to separate salt and other substances from seawater? This is what one class tried.

The class remembered that minerals were left behind when seawater evaporated. They also remembered that water can change its state from a liquid to a gas. You know that water can also change its state from a gas to a liquid.

They fitted one end of a plastic tube over the spout of a teakettle. They put the other end of the tube into an empty glass. They put the glass in a bowl of ice water.

With their teacher's help, they boiled some seawater in the kettle. Once the water started boiling, the students observed what happened.

The water in the kettle changed to water vapor. You may remember water vapor is a gas. The gas went into the plastic tube. When the water vapor came near the cold glass, the gas began to cool. The gas changed to a liquid. We say the gas **condensed.** The water vapor condensed to form liquid water.

condense
(kən·dens')

Was the water different from the seawater they started with? Here's what the class found out.

When the water in the glass had cooled, they poured some of the water into a clean dish. They waited until all the water had evaporated. Nothing was left in the dish!

Where were the salts and minerals from the seawater? They were inside the kettle, to be sure. The class had *distilled* the seawater. Distilled water is water without any minerals dissolved in it. The class had separated the water from the salt.

1. Tap water is used to water crops but seawater is not. Why?
2. Name several elements found in seawater. How is each element used?
3. Describe the changes that take place in seawater when it is distilled.

A Project: Watering Plants with Seawater

Fill 2 cups halfway with salt water. Fill 2 more cups halfway with distilled water. Label each cup. Get four spinach leaves about the same size. Put one spinach leaf into each of the cups. Let the spinach leaves soak overnight.

What does the salt water do to the spinach leaves? Which would be better for watering plants—seawater or distilled water? Why?

You might want to find out more about life in the oceans. Here is a book that includes many activities you can do.

Seas and Oceans (Turning Points), by Imelda and Robert Updegraff, published by Penguin Books, New York, 1983.

Riches from the Sea

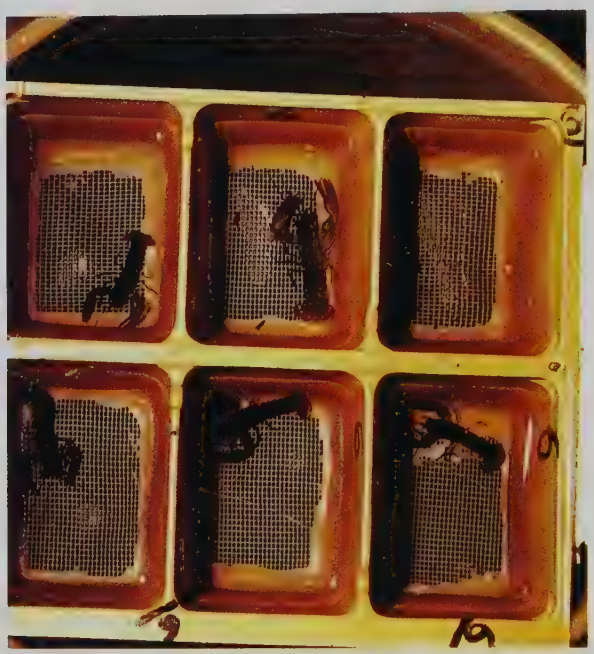
The early settlers who came to America crossed the sea in sailing ships. When they landed, they built their homes and towns near the ocean. In a strange new land it was good to be near the sea.

The ocean waters were rich with food. Along the shores and in shallow waters lived oysters, crabs, and other shellfish. These small sea animals were easy to catch. Larger food fish lived in other parts of the ocean. There were plenty of codfish and bass. There were salmon and tuna too. Yes, the ocean was a great bowl of food!

Today's fishing boats carry huge nets like this one. Tons of fish are pulled from the sea at one time. Salmon and tuna are taken from the sea along with other food fish and ocean plants.

Think about what happens when the last of a farmer's crops has been harvested. The farmer knows the farm will be planted once again. So, in a way, the farmer replaces what is taken from the land. How do we replace what we take from our oceans?

Here young fish are hatched. They are raised and cared for on *fish farms.* Lobsters are also raised on special farms. Some of these animals will be set free in ocean waters. Others will be used for food.



Scientists are trying to make the right kinds of environments for different kinds of sea life. Scientists are trying to make salt-water environments far away from the sea. This is a new technology, isn't it?

A farm is a special environment on land. A fish farm is a special environment for animals that live in water. Raising fish on fish farms has its problems. For example, the temperature of the water must be controlled. This and other problems are being solved.

Things You Know

1. Why did the early settlers call the sea a great bowl of food?
2. How is the food we take from a farm replaced?
3. Why are fish farms important?

Using What You Know

Write the answers to all questions in your science notebook.

A. Read each sentence. Use terms from the list below to fill in the blank spaces. You may use a term more than once.

bromine, condensed, desert, dissolved, distilled, evaporated, fish farms, magnesium, oceans, oysters, table salt

1. Almost three-fourths of the Earth's surface is covered by _____.
2. Minerals are left when seawater in a pan is _____.
3. The chief mineral in seawater is _____.
4. A metal element in seawater is _____.
5. It is too dry for most plants to grow in the _____.
6. We can't drink seawater because it has too much _____ in it.
7. Water without any minerals dissolved in it is _____ water.
8. Among the animals that live along the shores are _____.
9. To replace what we take from the ocean, we now raise some sea animals on _____.

B. Look at the picture. Then describe each thing that happens when you put seawater into the kettle.

Science and Technology:

Heating Homes

Wood, coal, and oil are made of matter. In other words, they are made up of atoms and molecules. How do we turn matter, say coal or oil, into energy? You know. We burn it.

When fuels are burned they give off heat. We use this heat to warm our homes. Our houses can stay warm even in the coldest winter.

How did people first burn wood or coal in their homes? The first technology for burning wood or coal was the fireplace. Then came the stove.

Today we may use a newer technology, such as burning coal, gas, or oil in a furnace. In a home, either air or water is heated in the furnace. The hot air can go right into rooms to heat a home. The hot water goes into radiators. Other homes use electricity for heat. How is your home heated?

Many factories, as well as homes, depend on oil heating. Without this technology, we would not have many of our largest cities.

Another View:

Where does matter we use come from?

We say we walk on the ground. Actually, we walk on planet Earth. Very few of us think that all we wear, all we eat, all we drink, comes from our planet. Think of it, cotton and linen for clothing come from the Earth. So do coal and oil for heating. So do leather and rubber for shoes. Some of our food comes from the Earth's oceans. So does much of the salt we use.

Look around you. See if there is anything in your room that did not come from the Earth. Is the Earth the source of all the matter we use?

Some people might say not all the matter we use comes from the Earth. Don't we use nylon that is made in the laboratory? Yes, but nylon is made up of the elements carbon, hydrogen, oxygen, and nitrogen. These elements come from the Earth. Of course, we use gasoline. But gasoline is made from oil. Surely, we can trace all the matter we use back to the Earth.

You Know A Great Deal

A. Choose the term that makes each sentence correct. Then write the letter of the term you choose in your science notebook.

1. A fiber made from an animal is
   a. linen b. rubber c. silk
2. A fiber made in the laboratory is
   a. wool b. nylon c. cotton
3. Prints of leaves found in coal are
   a. rocks b. charcoal c. fossils
4. Each of these is a fuel *except*
   a. petroleum b. sandstone c. coal
5. Coal was formed millions of years ago from
   a. dead trees b. tiny plants and animals c. muddy swamps
6. When coal is mined, it is found between layers of
   a. rock b. rock oil c. crude oil
7. Most of the fish early settlers ate came from
   a. fish farms b. the oceans c. the deserts
8. When you make distilled water from seawater, you must *take out* the
   a. minerals b. condensed liquids c. evaporated gases
9. In the ground, oil may be trapped in a layer of porous
   a. shale b. sandstone c. table salt
10. From petroleum, we can *not* make
    a. gasoline b. candle wax c. charcoal

B. Suppose you had the technology to bring seawater to the desert. Could you grow fruits and flowers? Why?

A Project: Growing Crystals

A crystal is a kind of solid matter. The atoms of a crystal line up in order. Many substances form crystals. For example, table salt found in seawater forms crystals. Use a magnifying glass to examine some table salt. Do you see small crystals that look like little cubes? Notice that crystals of table salt all have the same shape.

You can grow some crystals. Get some ammonium alum from a drug store. Make a solution of the alum and water. To make the solution, mix the alum with hot tap water until no more alum will dissolve. Let the solution cool. Put a paper towel in a funnel. Pour the solution through the paper towel into a clean, dry jar. Then leave the solution overnight. Do not move the jar.

Look at the bottom of the jar the next day. You'll see clear crystals of alum. Use a magnifying glass to observe the crystals. Are they the same shape as crystals of table salt?

Books For You:

Fuzz Does It! by Vicki Cobb, published by Lippincott, Philadelphia, 1982. This simple introduction to fibers of all kinds may interest you.

Coal, by Betsy Kraft, published by Watts, New York, 1982. If you want to learn more about how coal is formed and mined, read this book.

In the Ocean, by Charles Roux and Y. Verbeek, published by Silver Burdett, Morristown, New Jersey, 1983. This book explores our oceans and the various kinds of interesting plant and animal life in them.

Changing Energy

Look at the difference in the pictures. Clearly, the light is on in one picture. A flick of a switch, and there is light. A press of a button, and a bell rings. We switch channels on TV to get a new program. We turn the key in a car, and the engine starts. Energy is changed from one form to another.

Unit 3

Try this. Put your hands together palm to palm. Rub your hands together rapidly again and again. They get warm. Did you change one kind of energy to another?

By now you know that the Sun gives us most of our light energy. The Sun also gives us heat. But the Sun's energy can also be changed to electric energy. You'll soon learn how.

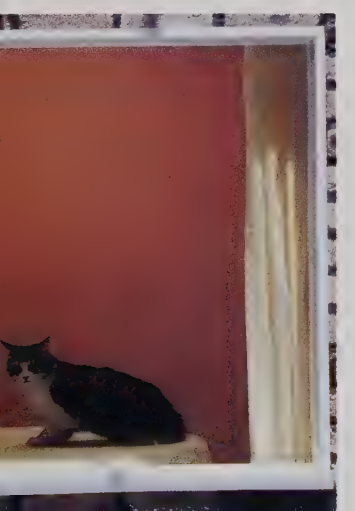
8

Energy All Around You – Light

Even on a cold, snowy day, the Sun may shine brightly. See how the icicles on the house sparkle. See how the snow glistens in the sunlight. Light is an important part of your environment. After all, you use light every day.

A

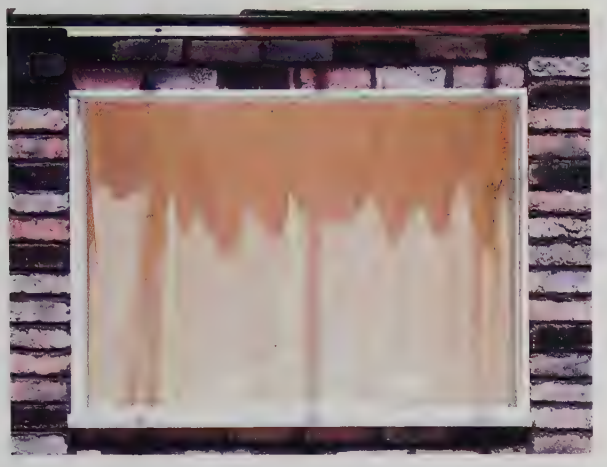
The Light You See

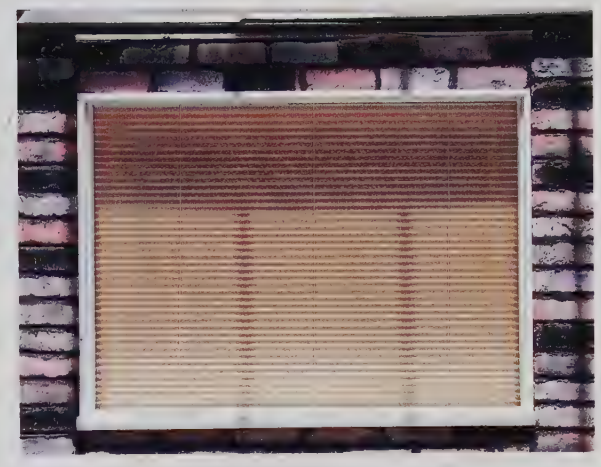


You know that light goes through some things. It's easy to see the kitten in the window. Light goes through the window glass.

Look at the kitten through the curtain. Less light goes through the curtain. It's much harder to see the kitten now.

No light goes through the window blinds. Can you see the kitten?





You know you need light to see the kitten. Where does the light come from?

Hold a piece of heavy brown paper up to the light. Part of a brown paper bag will do. Not much light goes through brown paper.

Rub some salad oil on the brown paper. Hold the paper up to the light again. More light goes through now.

Would oiled paper make as good a window as glass? Why?

Shadows

You can see through some things very well. Only a little light goes through other things. Name some things that light goes through. Surely you said a window or a thin curtain.

There are some things that light does not go through at all. Think about things around you that keep light out.

Light does not go through most solids. Here the tower blocks the light. The tower makes a *shadow* on the ground.

It is early in the morning. The Sun has just come up. The Sun is very low in the sky. Notice how long the shadow is.

Look at the first picture at the top of the next page. It is almost noon. The Sun is almost overhead. See what has happened to the shadow.

Look at the second picture. It is late afternoon. The Sun is going down. See how long the shadow of the tower looks now.

Look at the picture of the dog below. Decide what makes the shadow.

You can make shadows outside in sunlight. You can also make shadows indoors. Try making a shadow using a flashlight. What else will you need to make a shadow?

All things do not make shadows. Just those things that light can't go through make shadows.

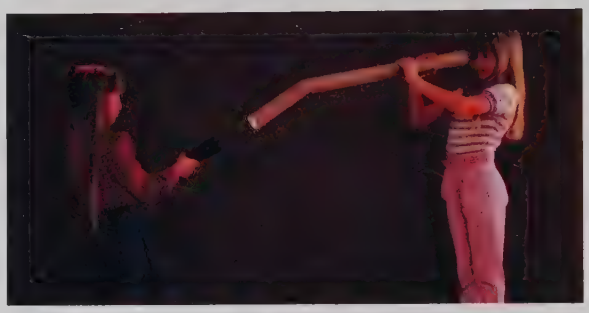
Do you think a glass of water would make a shadow? Find out. Explain what happens.

Finding Out:

How does light travel?

Ask a friend to turn on a flashlight in a dark room. Look at the light from the flashlight through a straight tube.

Bend the tube. Do you still see light? Does light travel in a straight line? Explain why you say so.



Put a mirror on a table. Shine the flashlight on the mirror. The light bounces off the mirror. Does the light bounce back in a straight line?

Perhaps light also bounces off a table. Try it and see.

Stand on one side of a wall. Ask another friend to stand just around the corner – on the other side of the wall. Be sure you can't see your friend. How can you use the mirror to help you see around the corner?

Light travels in a straight line. When light hits a mirror, the light bounces off. The mirror **reflects** the light. You see yourself in a mirror because light is reflected from the mirror back to you.

reflect (ri·flekt')

Here is a periscope. This periscope uses mirrors to reflect light. So you can use this kind of periscope to see over a wall.

Here is another kind of periscope. This periscope is on a submarine. Under the water, inside the submarine, the periscope makes it easy to see outside.

Things You Know

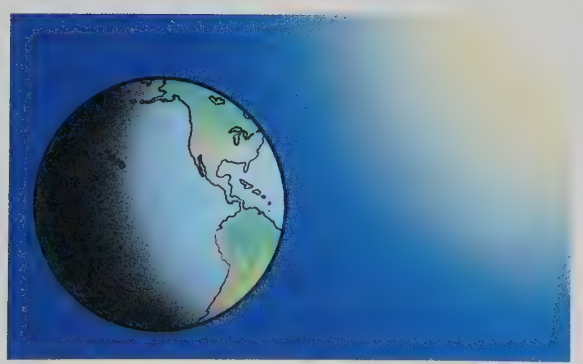
1. Why can you see through a window but not through a wood door?
2. Suppose you are outside all day. How does your shadow change from early morning to late afternoon?
3. How can you use a mirror to show that light travels in a straight line?

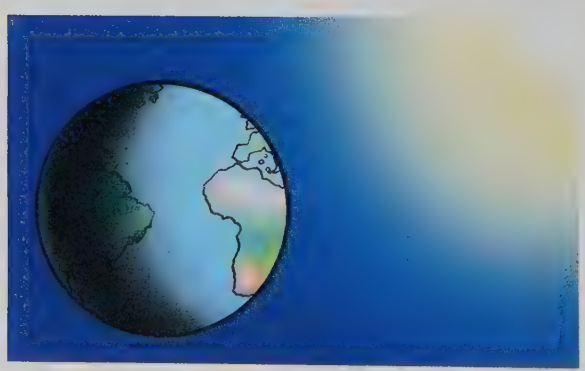
B

Light from Far, Far Away

Yesterday and today daylight reached us the same way. You know that light comes from the Sun. Won't daylight reach us the same way tomorrow?

Light from the Sun travels far through space to reach planet Earth. Sunlight travels about 150 million kilometers to reach us. The Sun's light shines on a large part of the Earth's surface at one time. So it is day on that side of the Earth. It is night on the other side.

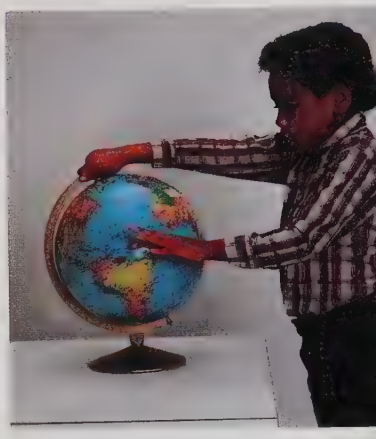




The Earth Rotates– A Model

Planet Earth turns. We say it **rotates.** As the Earth rotates, one side moves out of the sunlight into shadow. It is now night on that side of the Earth.

The Earth rotates once every 24 hours. As it rotates, the Earth seems to turn around a line through its center. This line is called the Earth's **axis.**



The Earth rotates around its axis much the same way a globe moves when you turn it. Notice that the axis of the globe isn't straight up and down. The axis is at an angle. Like the Earth's axis, the globe's axis is tilted.

Suppose you use a globe to stand for planet Earth. How could you show what happens as the Earth rotates in one day?

Here the light from a flashlight stands for the Sun. On which side of the globe, **A** or **B**, is it day? On which side is it night?

Look at the other picture. Is it day or night on the side marked **B**? What changed?

On a Moonlit Night

The Moon has no light of its own. Yet we can see the Moon shining at night.

Light from the Sun reaches the Moon. The Sun's light bounces off the Moon's surface. The Moon reflects light. So moonlight is really sunlight. Moonlight is really sunlight reflected to the Earth.

You know the Sun lights the Earth during the day. So, in a way, you can say the Sun also lights the Earth at night.

Things You Know

1. What do we mean when we say the Earth rotates?
2. The Moon has no light of its own. Then why does the Moon shine at night?
3. How can you use a globe and flashlight to show why we have day and night?

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

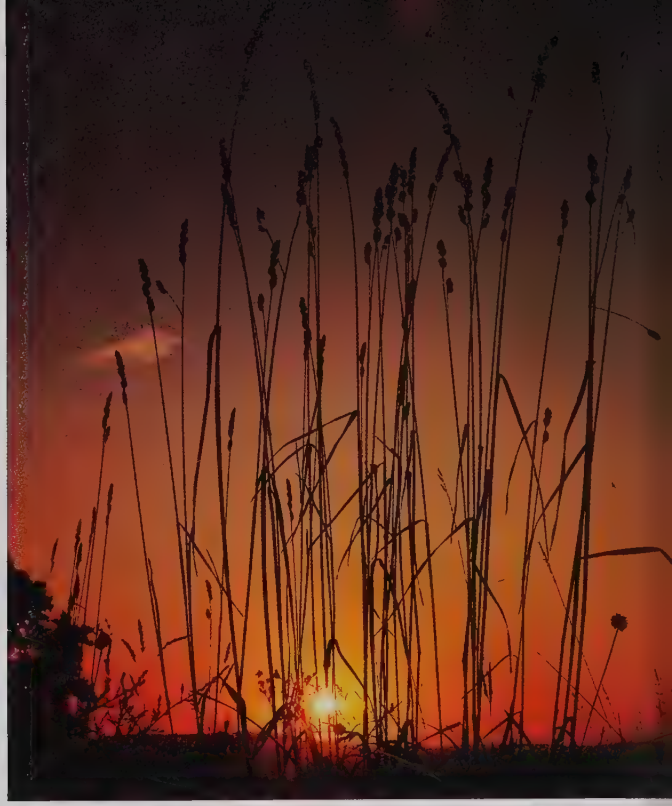
1. To see anything, you need (light, shadows).
2. Light goes through (oiled paper, most solids).
3. Shadows are longer (at noon, in the morning).
4. Light travels (around corners, in a straight line).
5. Planet Earth turns on its axis, or (rotates, reflects).
6. If you shine a light on a mirror, the light is (tilted, reflected).
7. The Earth rotates once every (12 hours, 24 hours).
8. We see the Moon by light reflected from the (Earth, Sun).
9. When it is day on one side of the Earth, on the other side, it is (day, night).

B. Answer each question.

10. What time was it when this picture was taken? Why do you say so?
11. Predict what the shadow would be like at noon.

9

A Closer Look at Light



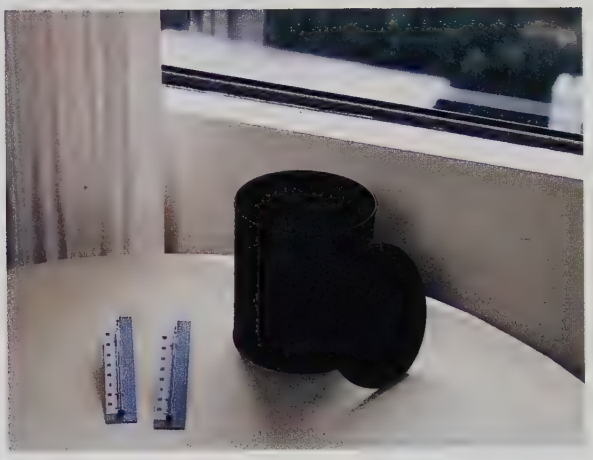
The Sun is just one of the billions of stars in space. Yet without its energy there would be no life on the Earth. You may know that light is a kind of energy. Light from the Sun is called **solar energy.** You use solar energy for light.

A
Light and Heat

In some places it's rarely cloudy. The Sun shines brightly day after day. In such places, people may use a solar cooker. A solar cooker uses solar energy to cook food. Why would you say a solar cooker is a kind of technology?

You need heat to cook something. In a solar cooker, light is changed to heat. From the picture, you can see how the cooker works.

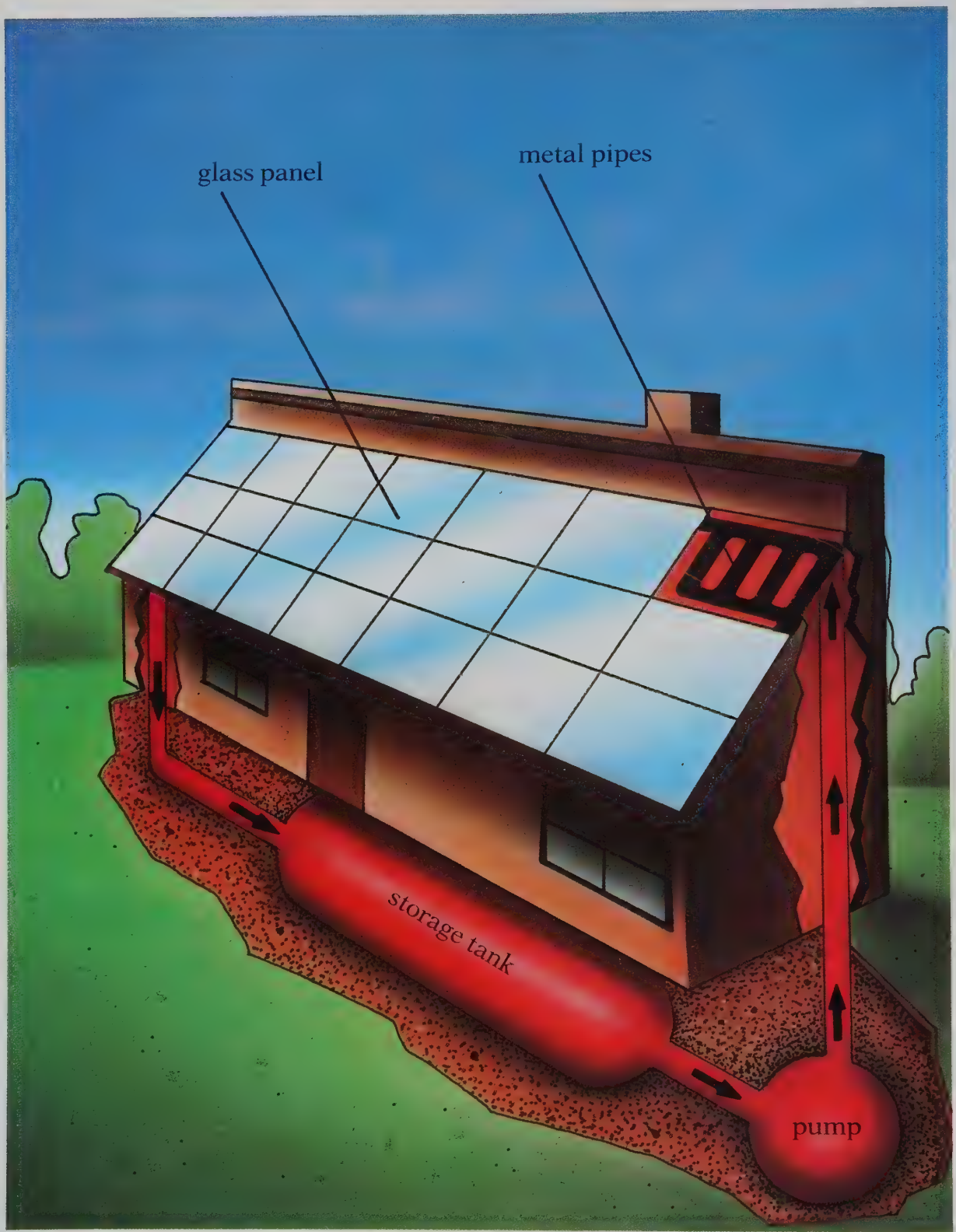
You will need a can and two thermometers. Paint the can black. Put the open can and the thermometers in a sunny spot for about 5 minutes. Be sure the thermometers are small enough to fit inside the can.



Wait until the thermometers reach the same temperature. Leave one thermometer out in the air. Put the other thermometer inside the can. Cover the can tightly. Leave the thermometer inside the can for 20 minutes. Then open the can.

Compare the readings of the two thermometers. Which thermometer shows a higher temperature – the one that was inside the can or the one that was outside? Where was there more heat?

Did the heat come from solar energy? Why do you say so?


glass panel
metal pipes
storage tank
pump

Changing Solar Energy

You now have evidence that energy can be changed from one kind to another. You know solar energy can be changed to heat. Heat is another kind of energy.

The air inside the can got hotter than the air outside the can. Solar energy heated the air inside the closed can.

This house uses solar energy for heat. Solar energy goes through the glass panels on the roof. Behind the glass panels are metal pipes. Solar energy heats water inside the pipes. The hot water moves down through other pipes. These pipes go all through the house.

The hot water loses heat to the room. The water gets cooler. The room gets warmer. The cool water is pumped back up to the roof. How does the water get hot again?

Things You Know

1. What is solar energy? Why is it important?
2. Describe the technology for using solar energy to heat a house.
3. How can you show your class that light can be changed into heat?

Light and Motion

radiometer
(rād·ē·äm′ət·ər)

This special glass bulb is a *radiometer*. The radiometer has a kind of wheel inside. Here the radiometer is in the shade. Does the wheel inside the radiometer turn?

Suppose you put the radiometer in sunlight. Now the wheel turns. How can you stop the wheel from turning?

It takes energy to move something. When a radiometer is put into sunlight, the wheel inside the radiometer moves. Solar energy makes the wheel move. So we can say that energy from the Sun moves things.

This photographer is about to take a picture. She needs to know if there's enough light. So the photographer uses a light meter. A light meter measures how much light there is.

Perhaps your teacher can bring a light meter to class. Find the needle under the glass.

Put the light meter in a dark corner. Notice where the needle points.

Bring the light meter near a lamp. Light makes the needle move. Put the light meter near a bright, sunny window. What happens to the needle now?

Where was there the most light? Again you have evidence that light is a kind of energy.

Things You Know

1. How does a radiometer show that light moves things?
2. Explain how a light meter can be used to measure light.
3. Does light have energy? Why do you say so?

A Book For You:

Would you like to have a race with the Sun, cook with the Sun, or use light from the Sun to print pictures? To find out how to do these and other exciting activities, read: *Sun Fun,* by Caroline Arnold, published by Watts, New York, 1981.

Using What You Know

A. Read each sentence. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. There would be no life on the Earth without the Sun's (energy, shade).
2. A thermometer is used to measure (light, temperature).
3. The wheel inside a radiometer is turned by (sunlight, heat).
4. In a solar house, as the solar-heated water cools, the house gets (warmer, colder).
5. Heat is a kind of (evidence, energy).
6. Making anything move takes (heat, energy).
7. A solar cooker changes light to (heat, water).
8. Light meters are used to (make, measure) light.
9. Bright sunshine makes the needle of a light meter (move, stop).

B. Why is this house called a solar house? Describe how a solar house is heated.

10

Electricity

The needle on the light meter moves. You know that light energy makes the needle move. But first the light energy is changed to *electricity*. You use electricity all the time. How can electricity make things move?

A
Rubbing Off Parts of Atoms

Tear a piece of paper into tiny bits. Bring a plastic pen near the bits of paper. Does anything happen?

Rub the pen on a wool sweater. Or perhaps you can use a piece of wool cloth. Bring the pen near the bits of paper again. What happens now?

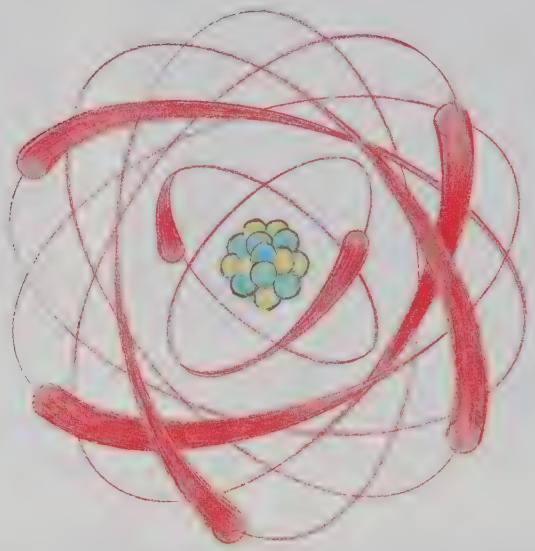
The pen picks up the bits of paper. We say the pen attracts the bits of paper. The pen seems to act like a magnet.

You know a magnet attracts paper clips. Try to pick up some paper clips with the pen. Does the pen attract the paper clips? No. The pen is not a magnet.

How then can we explain what happened? Remember, the pen didn't attract paper until you rubbed the pen with wool.

Parts of Atoms

Scientists have found that paper, a pen, and wool cloth are made of atoms. But we don't really know what atoms look like. You know scientists often use models to help them study things. This is one model of an atom used today.



nucleus (nü'klē·əs)

proton (prō'tän)
neutron (nu'trän)

electron (i·lek'trän)

In the center of the atom is the **nucleus.** The nucleus is made up of two kinds of tiny bits, or particles. These tiny particles are called **protons** and **neutrons.** As you can see, protons and neutrons are packed closely together.

Look at the other tiny particles that whirl around and around the nucleus. These tiny particles are called **electrons.**

The atom in the picture is an atom of nitrogen. The atom of nitrogen has 7 protons and 7 neutrons in its nucleus. Do you see the 7 electrons that whirl around the nucleus? Count them.

Electrons of any atom are always on the move. Some of these electrons can be rubbed off easily.

Extra Electrons

Recall what happened when you rubbed the plastic pen with wool. Many experiments have shown that some of the electrons in the wool rubbed off. The electrons went onto the pen. So the pen had some extra electrons.

A thing that has extra electrons can attract another thing that does not have extra electrons. You brought the pen, with its extra electrons, near the bits of paper. The pen attracted the paper. The pen had extra electrons. The bits of paper did not have extra electrons.

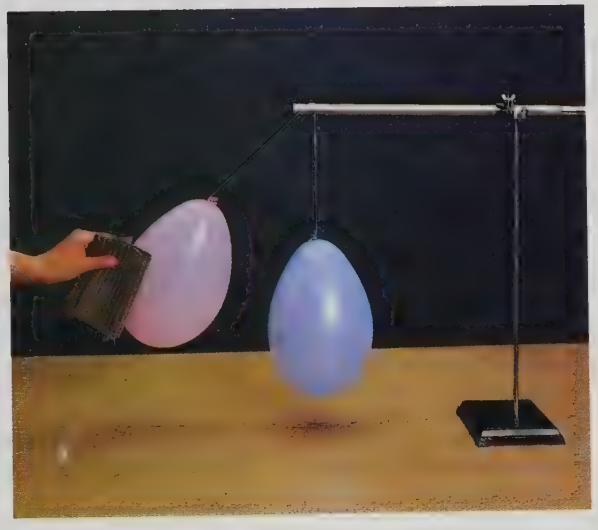
Things You Know

1. Draw a model of an atom. Show where the nucleus, the protons, the neutrons, and the electrons are.
2. A plastic pen attracts bits of paper. How can you show the pen is not a magnet?
3. Why does a plastic pen rubbed with wool attract bits of paper?

A Project: Finding Out More About Extra Electrons

Blow up two balloons and tie a string to each one. Then tie the balloons to a rod. Rub one balloon with a piece of wool cloth. What happens when you let the balloon swing?

This time, rub each balloon with the piece of wool cloth. Now each balloon has some extra electrons. Let the balloons swing. What happens? Try to explain what you observe.



B

Electrons on the Move

You may have walked on a carpet and then touched some metal. Perhaps it was a doorknob. You may have felt a shock. Perhaps you saw a spark. Let's find out why.

You rubbed your shoes on the carpet. Some of the electrons in the carpet rubbed off. The electrons went from the carpet to you. So you had some extra electrons. You touched the metal. The extra electrons jumped from your finger to the metal. The electrons caused a slight shock or spark.

Electrons can also flow from one place to another. That is what electricity is–a flow of electrons. A *steady flow* of electrons is called an electric **current.** When we say electricity, we really mean an electric current.

A flashlight is easy to use. Just push a switch and the bulb lights up. But a flashlight needs electricity. You know a flashlight gets electricity from dry cells.

This dry cell is made of a metal can wrapped with cardboard. In the center of the can is a black rod. A wet paste fills the can around the rod.

You probably call such dry cells "batteries."

The metal can is made of zinc. Zinc is an element that loses electrons easily. The black rod in the center is made of carbon. When the dry cell is used, electrons flow from the zinc to the carbon. An electric current is produced.

Finding Out:

How does a flashlight work?

Take a flashlight apart. Find the switch that turns the flashlight on and off. Then find the two dry cells. Take them out of the case.

Find the piece of glass or clear plastic that covers the bulb. The glass or plastic protects the bulb.

Take out the bulb. Find the piece of shiny metal around the bulb. What does the metal do?

Now put the flashlight back together. But don't put the dry cells back in the case. Does the flashlight work? Why not?

Put one dry cell back in. Be sure the end of the dry cell with the bump points toward the bulb. Try the flashlight again. Does it work now?

Will the flashlight work with two dry cells? Explain why.

When you switch on a flashlight, the zinc begins to lose electrons. The electrons flow through the bulb to the carbon. When you turn off the flashlight, the electrons do not flow.

You know dry cells do wear out. They work only as long as the paste inside stays wet. So a dry cell isn't really dry.

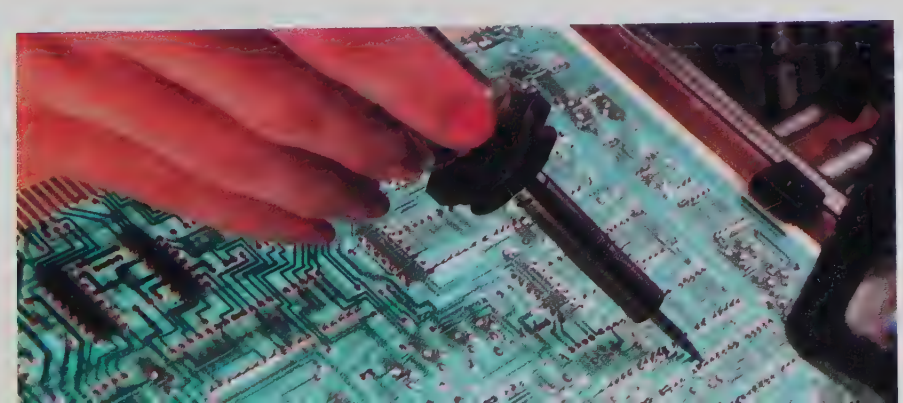
Things You Know

1. Suppose you walk on a carpet and touch a doorknob. Why may you get a shock?
2. What is electricity? What is an electric current?
3. Describe how dry cells make a flashlight work.

Careers: In Electronics

You may know that an electrician works with various things that use electricity – a flow of electrons. But people who work in electronics combine the action of electrons with technology. Radio, television, and computers are possible because of electronics. So are lasers and space satellites.

Technicians may build, operate, and repair electronic items. Engineers design and develop new electronic parts and equipment. Of course, there are people who work in factories that make different electronic items. Perhaps you would like to design or make electronic parts such as computer "chips."



Chapter 10

Using What You Know

Write the answers to all questions in your science notebook.

A. Read each sentence. Use terms from the list below to fill in the blank spaces. You may use a term more than once.

bulb, carbon, dry cells, electric current, electrons, protons, sparks, switch, zinc

1. Electricity is a flow of _____.
2. The nucleus of an atom has neutrons and _____.
3. A flashlight gets electricity from the _____.
4. In a dry cell, electrons flow from the _____.
5. In a light meter, light energy is changed to electricity, or a (an) _____.
6. To turn a flashlight on or off, use the _____.
7. A plastic pen that attracts bits of paper has extra _____.

B. Answer each question.

8. You slide across a plastic seat on a bus. Then you touch some metal. Explain why you get a shock.
9. The picture shows the parts of a flashlight. Explain how to put the parts together to make the flashlight light.

11

Changing Electric Energy

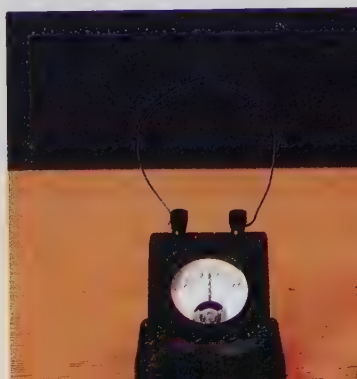
You know one kind of energy can be changed into another. In a radiometer, light energy is changed into the energy of motion. Light and other kinds of energy can be changed into electricity. An electric current can do many things.

To measure an electric current, you may use a meter like this one. When a current flows through the meter, the needle moves.

A

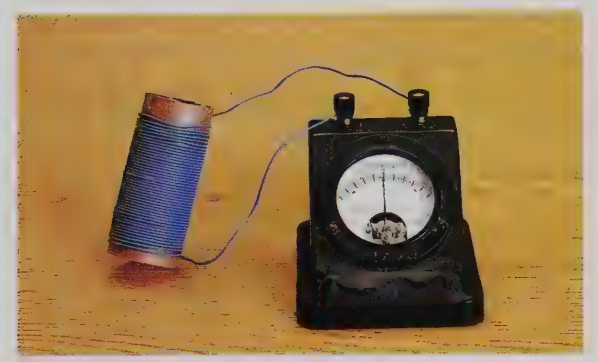
Measuring Electricity

You know electricity flows through wires. Suppose you connect the ends of a copper wire to the meter that measures electricity. Does the needle move? If not, no current is flowing. How can we get the electrons in the copper wire to flow?



Finding Out:

How can you make an electric current?



Make a coil of wire. Wind some wire around a cardboard tube 50 or 60 times. Ask your teacher to connect the ends of the wire to a meter that measures electric current. Does the needle on the meter move?

Quickly push one end of a magnet into the coil. What happens? Quickly pull the magnet out of the coil. Does the needle move again?

Now move the magnet quickly back and forth in the coil. Is a current flowing? How do you know?

Predict what will happen if you hold the magnet and move the coil back and forth. Try it. Were you right?

A Machine that Makes Electricity

When you move a magnet in a coil of wire, electrons flow. You found out that the magnet had to move to make electricity. Or the coil had to move. The magnet or the coil must keep moving or no electric current will flow. How can you keep the electric current flowing? Let's see.

This machine is made up of a magnet and a coil of wire. The magnet is shaped like a horse's shoe. A coil of wire is connected to a handle. When you turn the handle this machine makes electricity.

You could connect this machine to a meter that measures electricity. But suppose you connect the machine to a small light bulb instead. Now turn the handle very quickly. What happens to the bulb? Electricity must be flowing.

Things You Know

1. How can you use a magnet and a coil of wire to make an electric current?
2. Tell how you can get the needle on the meter in picture **a** to move.
3. You can use the machine in picture **b** to make electricity to light a bulb. Explain how.

a.

b.

A Project: Finding Out About Lightning

Look at the picture on the cover of this book. What do you think lightning really is?

You know the electricity that flows through wires and lights a bulb is called *current electricity*. You also know that extra electrons can flow quickly, or jump, from one object to another. The kind of electricity that jumps is called *static electricity*.

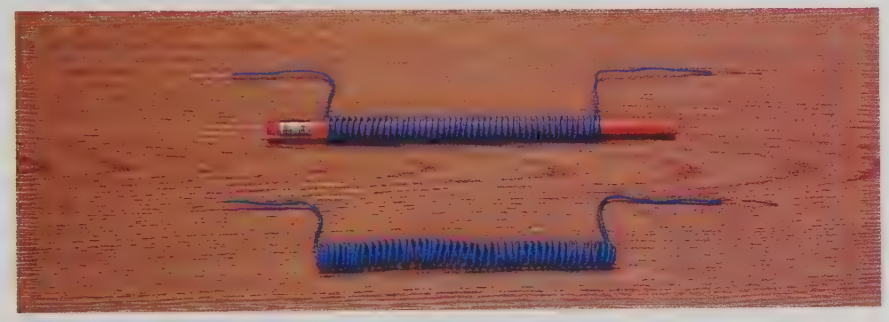
Static electricity can cause shocks and sparks. Lightning is really a giant spark that may happen when extra electrons jump from a cloud to the Earth.

Lightning can also be made by machines. You may want to find out about Van de Graaff generators. Such machines can be used to make static electricity in the laboratory.

Surely you have used a magnet in other ways. Perhaps the magnet was shaped like the one we just used. Perhaps it was shaped like a bar.

You know a magnet attracts things made of iron or steel, for example, paper clips or nails. But other metals, like copper and silver, are not attracted by a magnet.

Suppose you take a copper wire. Wind it around a pencil to make a coil. Remove the pencil.



Connect the ends of the coil of wire to a dry cell as you see here.

Now bring the coil near some small nails. The coil picks up some nails. The coil must be a magnet.

electromagnet
(i·lek·trə·mag′nət)

What happens when you send an electric current through a coil of wire? The coil becomes a magnet. In fact, the coil of wire becomes an **electromagnet.** Look at the two words that make up the word electromagnet. They are *electro,* for electricity, and the word *magnet,* of course.

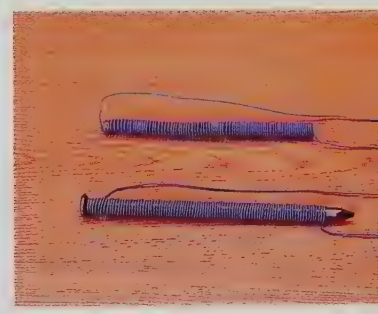
Suppose you make another coil of wire. But this time, wind the wire around the pencil many more times. Connect the coil of wire to the dry cell. Now bring some nails near the coil. Does the electromagnet pick up more nails this time? If so, you know the electromagnet is stronger. Why?

You can also make an electromagnet stronger by using more electricity. The extra electricity can come from another dry cell.

Perhaps there is yet another way to make an electromagnet stronger. Let's find out.

Finding Out:

Which electromagnet is stronger?



Use a large iron nail to make a coil of wire. Be sure to count the number of times you wind the wire around the nail. Remove the nail from the coil.

Make another coil of wire. Wind the wire around the nail the same number of times. But this time, leave the nail inside the coil.

Connect the coil without the nail to a dry cell. Bring the coil near some small nails. How many nails does the electromagnet pick up?

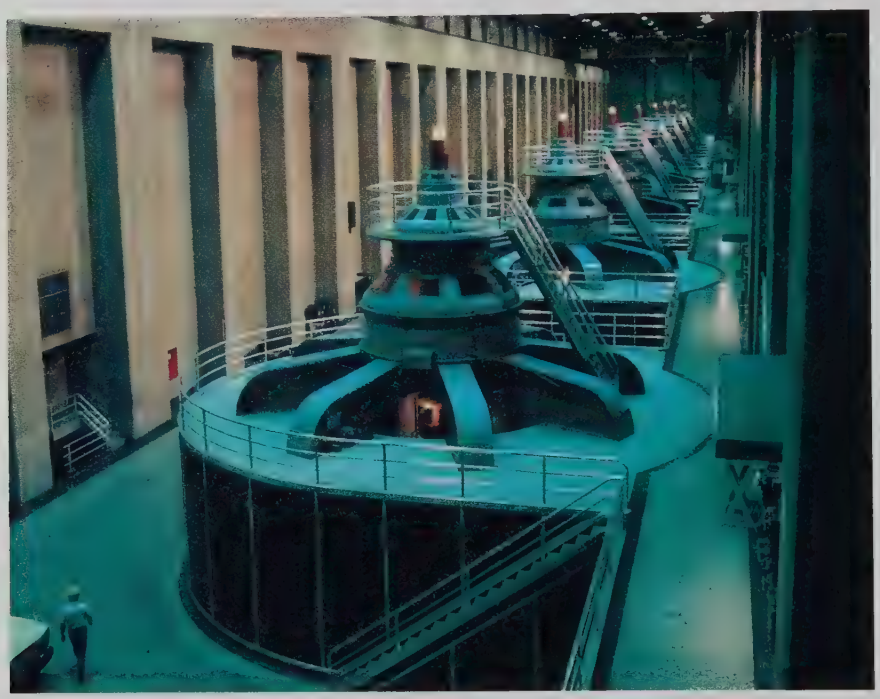
Do the same thing two more times. How many nails does the electromagnet pick up each time?

Now connect the coil with the nail to the dry cell. How many small nails does this electromagnet pick up? Try two more times.

Which electromagnet is stronger, the one with the nail or the one without the nail? Why?

These big machines make electricity. Inside the machines are huge magnets and coils of wire. The magnets are very strong electromagnets.

You saw a small machine light one small light bulb. You used your muscles to run the machine. You used your energy to make electricity. Of course, you can't use muscle to run huge machines day and night.



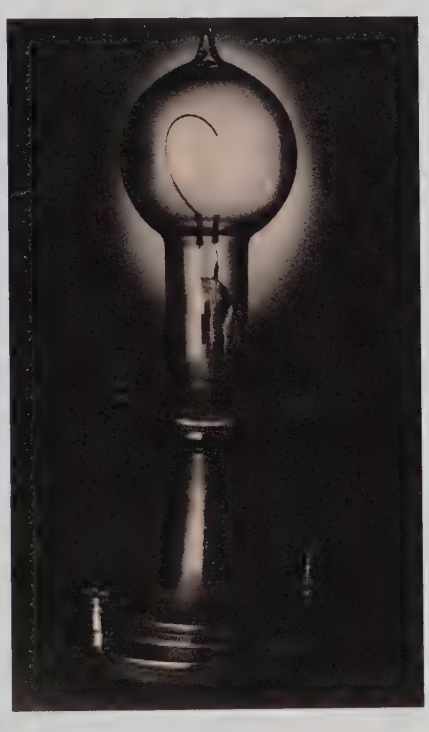
A great deal of energy is needed to turn the coils. Imagine how many bulbs these machines can light! Enough for a whole city, to be sure.

A Great Change

Had you lived only 150 years ago, you might not have heard the word "electricity." Candles, kerosene, and gas were burned to make light.

In 1879, Thomas Edison used electricity to light a small light bulb. Using electricity to make light was a change in technology.

Recall that technology can mean an invention to help us do something better. A kerosene lamp is one technology for making light. An electric light bulb is an example of a newer technology. A kerosene lamp burns fuel to make light. An electric light bulb uses parts of atoms–electrons.



Things You Know

1. How can you make an electromagnet?
2. What three things can you do to make an electromagnet stronger?
3. Describe the huge machines that are used to light the lights for a city.

Light and Electricity

Think about the light meter you saw earlier. Now let's see how some light meters really work.

Find the glass panel at the top of this light meter. The light shines on the glass panel. Under the glass panel is a metal plate made of the element selenium. When light shines on selenium, some of its electrons move.

The flow of electrons makes a current. This current moves the needle of the light meter. When more light shines on the selenium, more current flows. As long as light shines on the selenium, electricity flows.

What happens if you put your hand over the glass panel? You block the light. The light can't shine on the selenium. The electric current stops flowing. The needle doesn't move. If you take your hand away, the needle moves again. Why?

You probably know someone who uses a camera like this one. In this camera, the light meter is behind the small circle. When light shines on the meter, a current flows. This current controls how much light reaches the film.

You know that solar energy can produce electricity, heat homes, and cook food. But did you know solar energy can be used to make a plane fly?

It looks as if the wings and tail of this plane are covered with patches of glass. But each patch is really made of the element silicon. When sunlight shines on silicon, the electrons in the silicon flow.

The silicon patches change solar energy to electricity. That's why we call these patches *solar cells.* A solar cell makes only a small amount of electricity. So thousands of solar cells are needed to fly this plane.

No, the wings on this spacecraft aren't used for flying. They are used to make electricity. The solar cells change sunlight to electricity. The electricity keeps the machines inside the spacecraft working.

Solar cells don't wear out the way dry cells do. That's one reason solar cells are used on spacecraft.

Things You Know

1. How does a solar cell work?
2. Why are solar cells used on the wings of some spacecraft?
3. When light shines on the selenium in a light meter, current flows. Explain why.

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. We measure an electric current with a (coil, meter).
2. Moving a magnet in a coil of wire makes (electricity, an electromagnet).
3. A coil of wire and a dry cell may act like a (light bulb, magnet).
4. Two elements that change light to electricity are selenium and (iron, silicon).
5. Solar energy is changed to electricity in (electromagnets, solar cells).
6. Of these two, the newer technology is the electric (wire, light bulb).
7. Solar cells are often used to run machines in a (spacecraft, large city).

B. Answer each question.

8. Describe three ways to make an electromagnet stronger.
9. How can you make the bulb in the picture light? Explain why it lights.

Science and Technology:

Using Electricity

Wonderful technologies were invented once scientists discovered how to produce electricity. Then engineers and inventors used this new knowledge. For example, Thomas Edison invented a light bulb, a phonograph, and one of the first movie machines.

Once batteries were invented, automobiles could be started easily. Without electricity there would be no electric motors and no electric generators. And of course, no radio or TV. Science and technology depend on each other.

Before television was invented, people had to go to a movie house to see movies. Now the technology of television lets you see movies at home. You may hear the news and see sports on television. You may learn about an important new discovery. You may even "visit" other lands.

You have probably seen at least one new technology on television – the Space Shuttle. The Space Shuttle is the first machine to make round trips into space. The Space Shuttle depends on a technology that would not be possible without electricity. Give one reason why.

How has electricity changed our lives?

A hundred years ago, what did people depend on for light? The Sun, of course. This is still true.

As the Earth turns on its axis, part of it turns into the Sun's light–daylight. As the Earth keeps turning, part of it turns away from the Sun–darkness.

People discovered fire. In time, they learned how to make fire. They learned to light the darkness. There were candles. Then there were oil lamps. Then gas lamps. Then electricity.

The work of many scientists made electricity possible. Here are three of the important discoveries they made.

1. A coil of wire can become a magnet. To make the coil a magnet, we send electricity through the coil.
2. When a magnet is moved inside a coil of wire, electricity flows in the wire. When a coil is moved inside a magnet, electricity also flows.
3. Electricity is a flow of electrons.

Many technologies are based on these three discoveries. Electricity can be used to light a home, run a TV or radio, or run the machines inside a spacecraft.

Unit 3

You Know A Great Deal

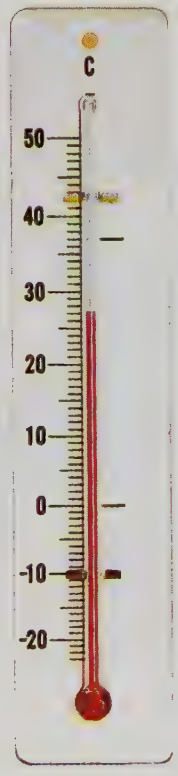
A. Choose the term that makes each sentence correct. Then write the letter of the term you choose in your science notebook.

1. When light hits a mirror, the light
   a. is reflected **b.** makes shadows **c.** rotates
2. Temperature is measured with a
   a. light meter **b.** radiometer **c.** thermometer
3. Electricity is a flow of
   a. protons **b.** electrons **c.** neutrons
4. A flashlight gets its energy from
   a. dry cells **b.** solar cells **c.** a light bulb
5. Moving a magnet in a coil of wire makes
   a. extra atoms **b.** an axis **c.** an electric current
6. A coil of wire and a dry cell connected together make
   a. a solar cell **b.** an electromagnet **c.** a meter
7. To heat a solar house, we do *not* need
   a. metal pipes **b.** glass panels **c.** solar cells
8. To make an electromagnet stronger, add more
   a. coils of wire **b.** switches **c.** magnets
9. In this machine, our energy is changed *first* into
   a. heat
   b. electricity
   c. light

10. In a dry cell, electrons flow from the
    a. zinc can **b.** wet paste **c.** carbon rod

B. Describe how each of these changes one kind of energy into another kind of energy: solar cell, solar cooker, dry cell.

A Skill of the Scientist: Reading a Thermometer



You can read the temperature on a Celsius thermometer for yourself. In the center of the thermometer is a glass tube with red liquid in it. Find the numbers and lines next to the glass tube. The numbers stand for degrees of temperature. We use the symbol ° for degrees.

There are three kinds of lines. Long lines are next to the numbers. In between are shorter lines. Look between 20° and 30°. There are nine shorter lines. Each short line stands for one degree of temperature. Do you see anything different about the line for 25°? It's shorter than the line for 20° or 30°. But it is longer than the other lines.

Look at the Celsius thermometer in the picture. To read the temperature, find the line nearest the top of the red liquid. What number does the line stand for? You have just read the temperature in degrees Celsius.

Books For You:

Discovering Electricity, by Rae Bains, published by Troll, Mahwah, New Jersey, 1982. Read this exciting book to find out how electricity is produced, controlled, and used.

Mirror Magic, by Seymour Simon, published by Lothrop, New York, 1980. Would you like to learn how different kinds of mirrors reflect light and how they are used? Then you will find this book very interesting.

Solar Power, by Ed Catherall, published by Silver Burdett, Morristown, New Jersey, 1981. This book describes solar power and different kinds of solar machines.

Energy We Use

Both machines use the energy of *molecules*. However, they use different kinds of molecules. Do you know the difference? In the first picture, molecules of water are heated by the energy in the burning wood. The heat causes the water to boil and change into steam.

In the other picture, molecules of gasoline are burned in the car's engine. The heat forces the

Unit 4

molecules of gasoline to move faster and farther apart.

What is alike in these two examples? In both examples, molecules are moving very, very fast. They are moving far apart. Can moving molecules make other things move?

You may have observed a rocket blast off–on TV. The rocket burns special fuel. The molecules of fuel move faster and farther apart. Hot gases come out of the rocket. What happens?

12

Another Look at Matter

The solid in this picture is gold. One of the liquids is water. The other liquid is mercury. How are these three things alike? Yes, all are matter. Two are elements. One is a compound. Which one?

A

Atoms and Molecules

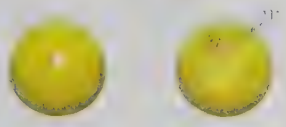
oxygen

nitrogen

Recall that elements and compounds are made up of atoms. Some atoms can join together, or combine. For example, two atoms of oxygen can combine. Together they make a **molecule** of oxygen. When two atoms of nitrogen combine, they make a molecule of nitrogen. Molecules are made up of atoms.

Suppose we use balls to stand for atoms. A model of an oxygen molecule might look like this. A model of a nitrogen molecule might look like this.

Each of these balls stands for a hydrogen atom. Two atoms of hydrogen can combine.

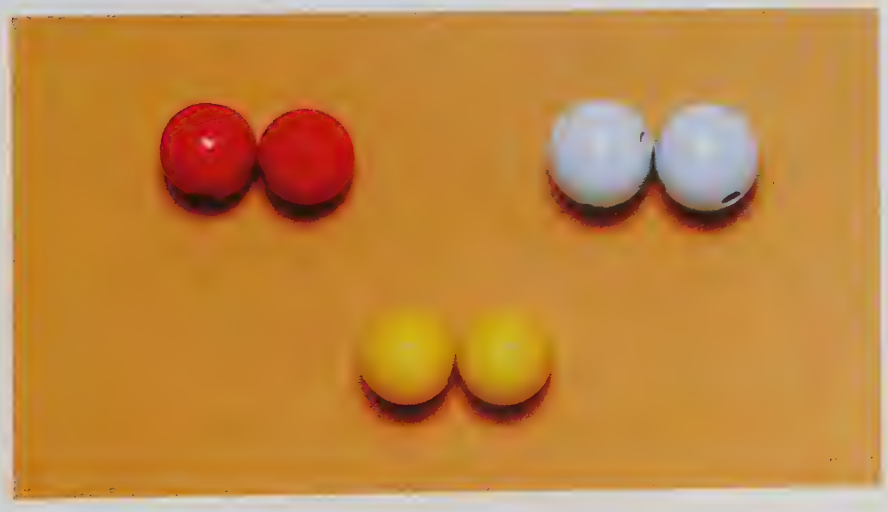


Make a model of a hydrogen molecule. Does your model look like this one?

hydrogen

How are molecules of oxygen, nitrogen, and hydrogen alike? Study the models once again. Notice each molecule is made up of two atoms. And the atoms in each molecule are both the same kind. Then these molecules must be molecules of elements.

Some molecules are made up of different kinds of atoms. Remember these molecules are called compounds.

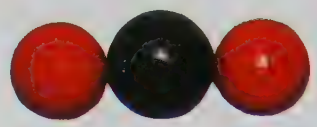


water

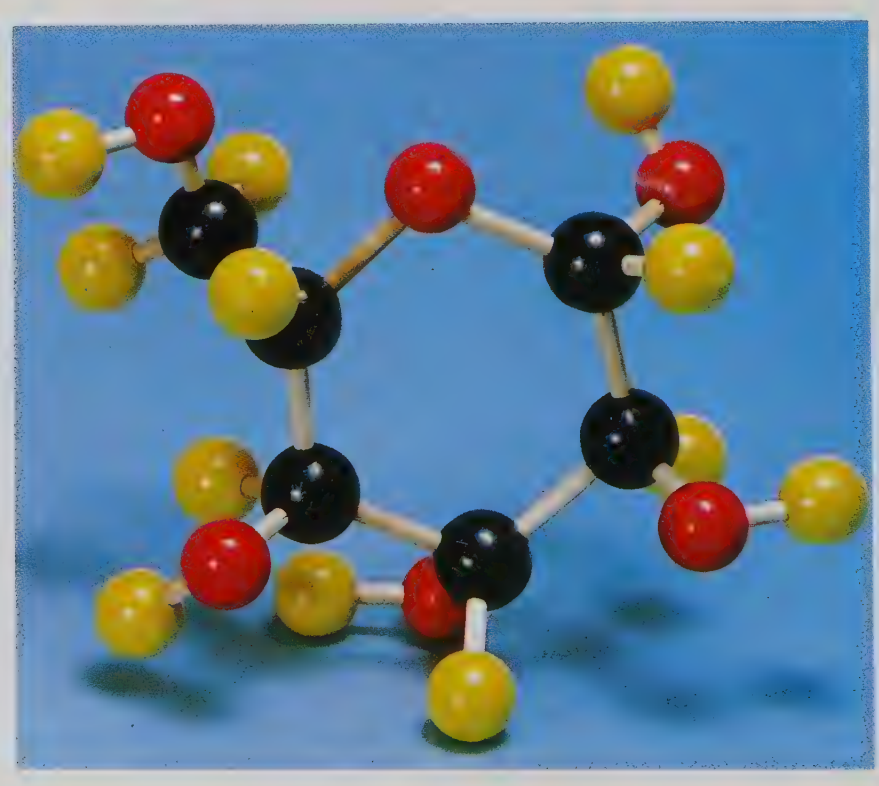
Water is a compound of hydrogen and oxygen. Two atoms of hydrogen and one atom of oxygen can combine to form a molecule of water.

When one atom of carbon combines with two atoms of oxygen, a molecule of carbon dioxide is formed. You know oxygen is a gas you breathe in. Carbon dioxide is a gas you breathe out. Carbon dioxide is also one of the gases plants use.

carbon dioxide



This is a model of the compound sugar. A molecule of sugar is made up of three kinds of atoms. Hydrogen and carbon atoms are parts of a sugar molecule. What is the third kind of atom you see?



sugar

The Smallest Part

Suppose we could divide water into very small parts. The smallest part we could get would be a molecule of water.

Suppose we could divide molecules of water into smaller parts. We would have atoms of hydrogen and atoms of oxygen. But these atoms would no longer be combined to make water. So a molecule of water is the smallest part of water we could get. The smallest part of the compound water is a molecule of water.

Things You Know

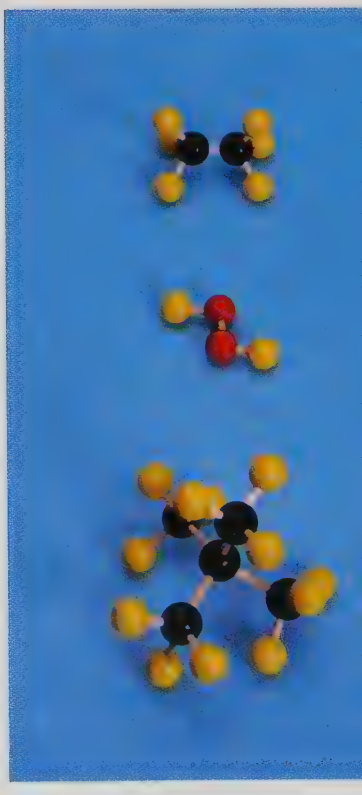
1. Is an atom or a molecule the smallest part of water? Why?
2. How is a molecule of an element different from a molecule of a compound?
3. Draw models of each of these molecules: hydrogen, oxygen, water, carbon dioxide.

A Skill of the Scientist: Writing Formulas

Look at the model of a molecule of ethane. Count the number of atoms of each kind in the molecule. Remember that black stands for carbon and yellow stands for hydrogen. Do you find 2 atoms of carbon and 6 atoms of hydrogen in the molecule?

Chemists use the letter **C** for carbon and the letter **H** for hydrogen. They write ethane as C_2H_6. Notice the number 2 after the **C** tells how many atoms of carbon are in the molecule. What does the number 6 after the **H** tell you?

Chemists call C_2H_6 the formula for ethane. Try to write the formula for hydrogen peroxide and for pentane—the other two molecules in the picture. Remember that red stands for oxygen. Use the letter **O** for oxygen in writing formulas.



B

Moving Things We Cannot See

Perhaps you have ridden a bicycle. Whenever you move something, you can usually see it move. You can also see what makes it move.

Gently add a few drops of ink to a glass of still water. What happens to the ink? Most of the ink falls to the bottom of the glass. Where does the rest of the ink go?

Slowly, slowly the ink moves and mixes with the water, even though the water looks perfectly still. A few hours later, the ink and water have mixed.

Molecules of water and of ink are always moving. As the molecules bump against one another, they mix. We can't see the molecules move. Yet we know they move because the ink and water mixed.

From many experiments, scientists have discovered that molecules are always in motion. Sometimes they move slowly, sometimes quickly.

Molecules in air are also moving. We can make the molecules in water and in air move faster. We can stir the water or fan the air. Perhaps there is another way.

Get two bottles of the same kind. Use bottles that are narrow at the top. Fasten a balloon over the top of each bottle.

Stand each bottle in a Pyrex bowl filled halfway with cool water. Put one bowl on a hot plate. Leave the other bowl on the table. Now turn on the hot plate.

Observe what happens to each of the balloons. Why does one balloon get larger? How could you make the other balloon get larger?

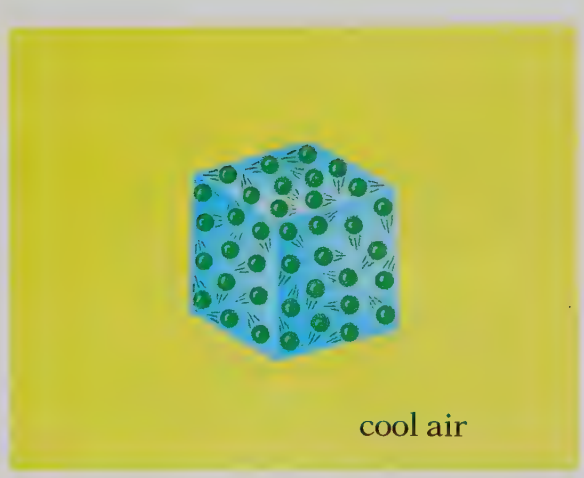
A Balloon Expands

Molecules of air are always moving. They are moving even when the air seems still.

You know there is air inside the bottles. There is also air inside the balloons. One balloon got larger. How can we best explain what happened?

You have some observations to help you. You put two bottles with balloons on them into bowls of cool water. When you heat the water in one of the bowls, the air inside the bottle gets warmer. The balloon gets larger. We say the balloon **expands.** But the balloon on the bottle in cool water does not expand.

We know air is made up of molecules. In the picture, the green dots stand for molecules. The molecules in air are always moving. As they move, the molecules bump and bounce off one another. Warm them, and the molecules move more quickly. Cool them, and they move more slowly.



cool air

warm air

When you heated the water, the hot water heated the air inside the bottle. As the molecules of air got warmer, they began to move faster. As they moved faster, they bumped and bounced harder. Then the molecules moved farther apart. The air expanded.

As the space between the molecules in the air got larger, the air took up more space. The expanding air pushed up into the balloon. Soon the balloon was filled with moving and bumping molecules. These moving molecules made the balloon expand.

Why didn't the balloon on the bottle in cool water expand? What could you do to make it expand?

Things You Know

1. You add a few drops of red ink to a glass of water. Why does all the water turn red in a few hours?
2. Suppose you put a bottle with a balloon on it into a pan of hot water. Why does the balloon expand?
3. If you cool the bottle with the balloon, the balloon gets smaller. Why?

C

Moving Molecules in Matter

You know solid ice can change into liquid water. And liquid water can change into water vapor, a gas. These substances are made up of the same kind of molecules.

We say that water can change from one state to another. Water can be in the solid state. Or water can be in the liquid state. Or it can be a gas. How is this possible?

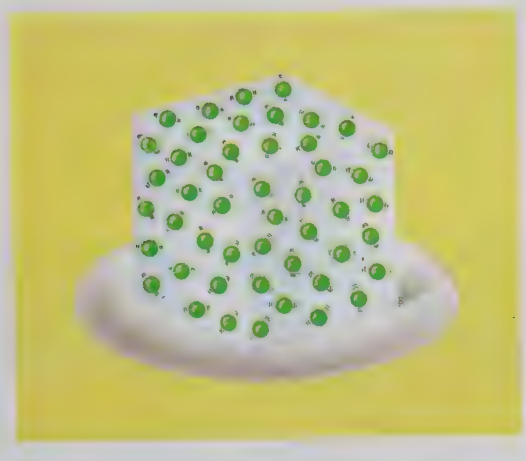
When scientists try to explain their observations, they may form a **theory.** A theory is an explanation of what they have observed. A theory is an explanation of facts. Scientists have formed a theory that explains how matter can change its state. Matter can change from a solid to a liquid. Or matter can change from a liquid to a gas.

theory (thēə·rē)

A Theory About Moving Molecules

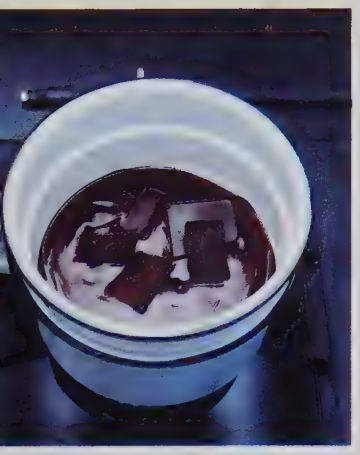
Think about the molecules in a solid, a liquid, or a gas. Think of the molecules in a solid, such as sugar. Think of the molecules in a liquid, such as water. Now think of the molecules in a gas, such as air.

Perhaps models would help. In these models, the dots stand for molecules. The molecules in a solid are always moving. But in a solid, molecules move slowly. They don't bump and bounce very much. The molecules cannot move around freely. The molecules are closely packed.



In a liquid, the molecules are moving faster. The molecules are not so closely packed.

In a gas, the molecules are moving very fast. The molecules are also very far apart. Molecules in a gas can move around freely.



You know heat makes molecules move faster. So when you heat a solid its molecules speed up. They bump and bounce harder. They begin to move apart. The solid may melt. It may change to a liquid.

Heat also makes the molecules in a liquid move faster. As the molecules move faster and faster, the liquid becomes a gas.

Perhaps you can now form a theory about moving molecules. Perhaps you'd say something like this.

Molecules in matter are in motion. The molecules move slowly in solids. They move faster in liquids. They move fastest in gases.

Let's call this theory the *Theory of Moving Molecules In Matter.* This theory explains what you see around you.

Scientists use this Theory of Moving Molecules to explain how matter can change its state. It is a theory that explains what they have observed.

Do scientists ever change their theories? Of course they do. They change their theories as new facts are found. If the new facts do not fit the theory, a new theory is stated.

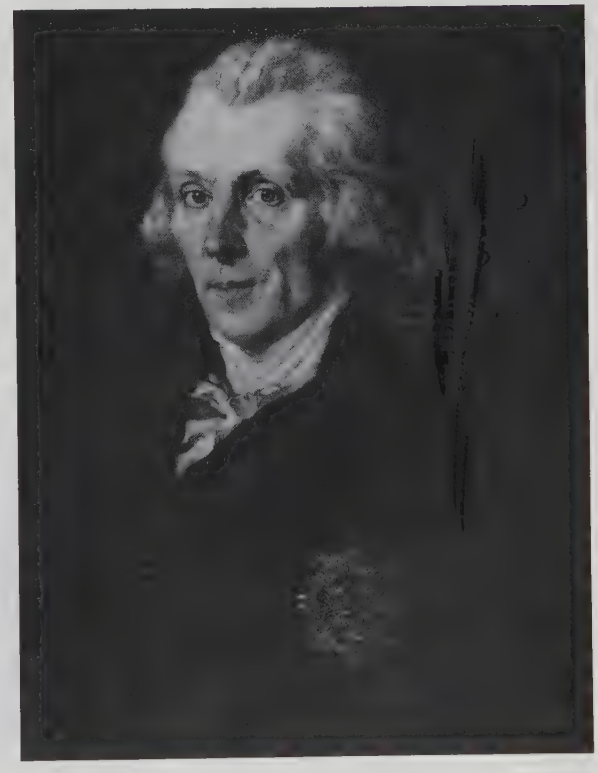
Things You Know

1. What are the three states of matter? Use water to give an example of each state.
2. Use the *Theory of Moving Molecules* to explain how matter can change its state.
3. What is a theory? Do scientists ever change a theory? Why or why not?

Finding Out in the Library: A Theory That Has Changed

You know that the Theory of Moving Molecules explains why matter changes state. This theory also explains why a balloon expands when it is heated. If you had lived 200 years ago, you would have used a different theory to explain these changes. You would have used the Caloric Theory of Heat.

Find out what the Caloric Theory of Heat was. How did this theory explain why a balloon expands when heated? How did this theory explain changes of state? Also find out what Count Rumford did. What observations made him think the Caloric Theory was not correct?



Chapter 12

Using What You Know

Write the answers to all questions in your science notebook.

A. Read the sentences below. Use terms from the list below to fill in the blank spaces.

apart, breathing, compounds, expands, heat, melts, model, molecule, moving, states, theory

1. Two atoms of oxygen join together to form a (an) _____.
2. Atoms of different elements combine to form _____.
3. Molecules are always _____.
4. When a gas is heated, it _____.
5. Solids, liquids, and gases are _____ of matter.
6. Scientists explain their observations and facts with a (an) _____.
7. Heating molecules makes them move _____.

B. Study the models of molecules. Then answer these questions.

8. When these molecules form a liquid, we call it water. What is it called as a gas? What is it called as a solid?
9. How could this matter be changed from one form to another?
10. In which state do the molecules move slowest?
11. What is each molecule made of?

13

Doing Work

You know heated air made a balloon expand. Would it surprise you that the air did work? That is, moving molecules in air did work.

Tina is about to leave for school. She lifts her books off the table. She says "Goodbye," as she opens the door. Does Tina do work? Let's see.

A

Work: The Scientist's Meaning

You have been learning about the ways of scientists. Scientists often write about what they do. They also talk to others. So what scientists write and say must be clearly understood.

Suppose you used the word "gas" when you were talking about a solid. Other people wouldn't know what you meant.

To the scientist, the word **work** has a special meaning. Scientists say work is done when a thing moves. This is not all there is to work, but it will do for now.

Remember when you heated the molecules in air inside a balloon. The molecules pushed against the balloon. The balloon got larger. The balloon moved. Work was done.

When Tina lifted her books off the table, she moved the books. Work was done.

Did Tina do work when she pulled the door open? Explain why you think so.

Now look at these two pictures. In which picture is work being done? Why do you say so?

Clearly, things do not move by themselves. What do you need to make something move?

Look once again at the boy pushing the piano. No doubt, he is pushing as hard as he can. Scientists say he is exerting **force.** He is exerting all the force he has.

A force is a push or a pull. It takes force to make something move. Does it take force to do work? Of course it does. You do work when you push or pull something. Work is done when a force makes something move. The force of the moving molecules in heated air made a balloon expand.

Does the boy pushing the piano do work? You would be right if you said, "No." The piano he is pushing does not move. And no work is done unless something moves. No matter how much force is exerted, no movement–no work.

The children are exerting a force. How can you tell if work is being done?

Is work being done in the other picture? Explain your answer.

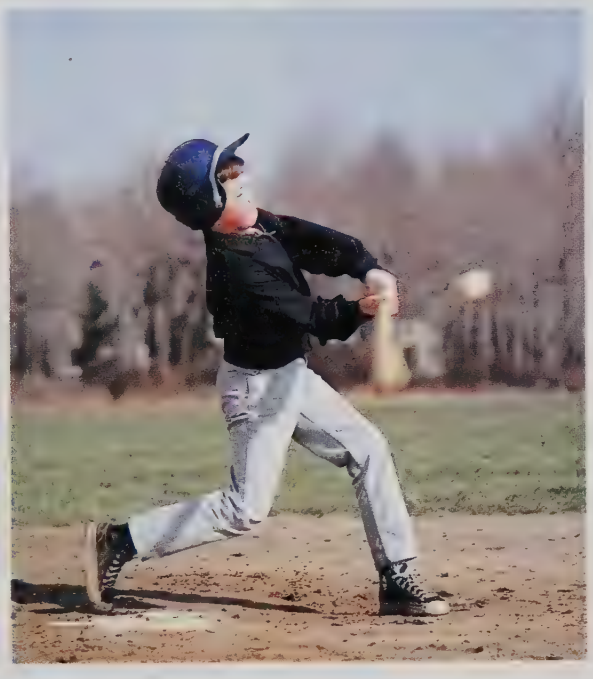
One of the children in this picture is doing work? Which child is it? What kind of force is the child exerting?

Things You Know

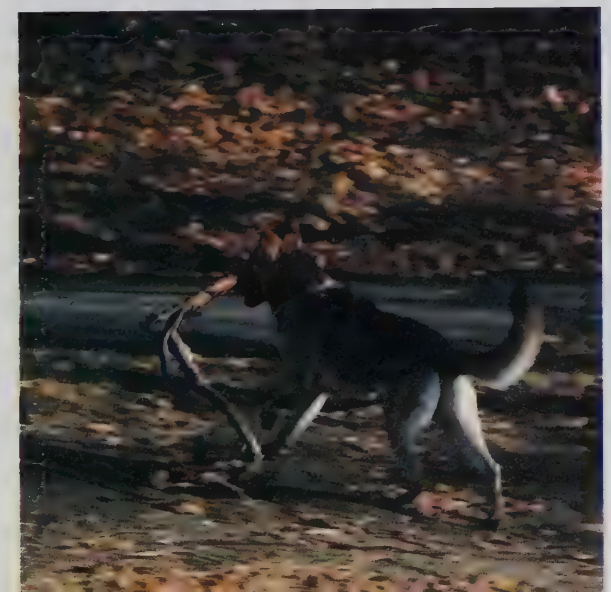
1. What does a scientist mean by the word *work?*
2. In what two ways can you exert a force?
3. You exert a large force on a very heavy box, but the box does not move. Are you doing work? Why or why not?

Energy for Work

You do work when you pull a sled through the snow. You do work when you hit a ball with a bat.



Examine these pictures. What work is being done in each picture?



You lift a box from the floor. You put it on a table. You exert force. Perhaps it is better to say your muscles exert force. The box moves. Work is done.

Whenever you move something you exert force. To exert force takes energy. So when you do work, energy is used.

You may know your body gets energy from the foods you eat. When you use your muscles to exert force, you use the energy you get from food.

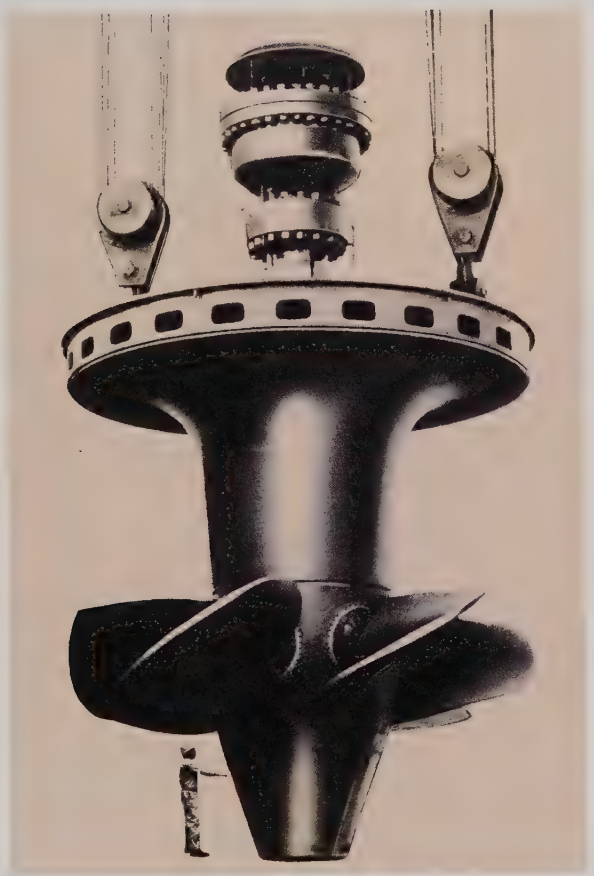
Today, most work isn't done by muscle. Most work is done by machines. Where do we get energy to run our machines?

Look at the waterfall. It can do work. It can move things. Put a wheel under falling water. The wheel turns. The water exerts force on the wheel. The wheel moves. Work is done.

When something can do work, we say it has energy. *Energy is the ability to do work.* Falling water has energy. So falling water has the ability to do work. The force of the water turns the wheel.

Today we use the energy of moving water to turn wheels of huge machines. These machines are used to make electricity.

You may have seen a windmill like this one. Windmills are machines run by the energy of moving air. Windmills are evidence that air can do work.



When a windmill turns, it can pump water from underground wells. Or the windmill can be used to make electricity.

Moving water and moving air have the ability to do work. In other words, moving water and moving air have energy.

Study the pictures below. From the pictures, you have evidence that work is being done. Why would you say a candle has energy?

Things You Know

1. When you do work, energy is used. Where does your energy come from?
2. What evidence do you have that air has energy to do work?
3. How is the energy of falling water used to make electricity?

C

Energy from Fuels

You know heat can make molecules move. So heat has the ability to do work. You also know heat can keep you warm on a cold day. Where does the heat you use come from?

Perhaps electricity heats your home. Or perhaps your home uses solar energy for heat. But most homes use some kind of fuel for heat.

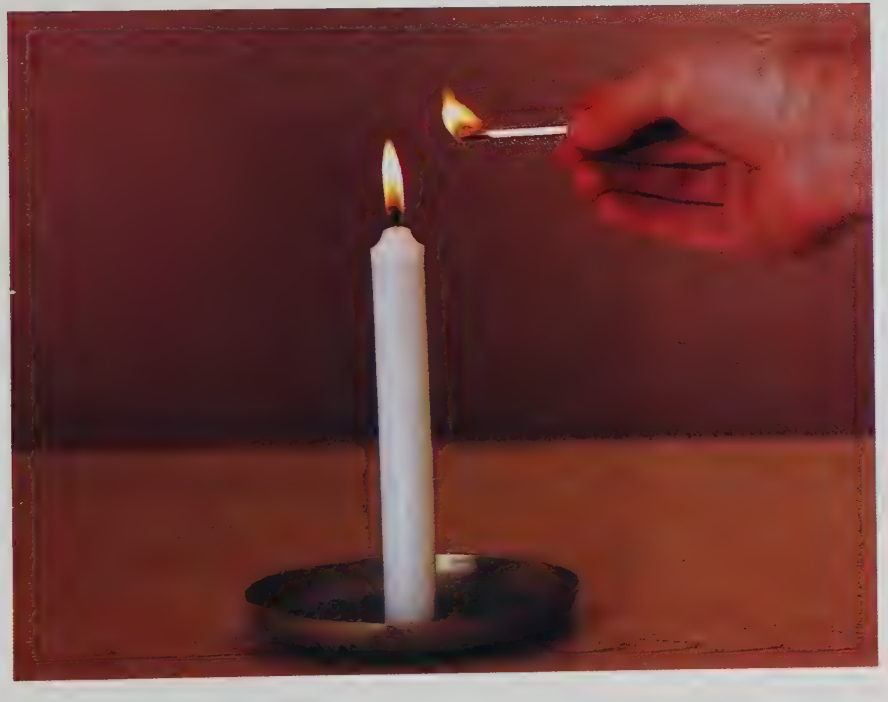
You may have used coal or wood to keep warm. Perhaps your home uses heat from oil or natural gas. Then you use the energy in fuels for heat. Let's see where the energy in fuels come from.

You may know that plants use energy from the Sun to grow. And plants store some of this solar energy.

The plants that lived millions of years ago stored solar energy as they grew. When these plants died, they changed. Slowly some plants changed to coal. Tiny plants and animals that lived in the oceans changed to oil. Some changed to gas which was stored in the Earth.

Anything that can burn has a store of energy. This is true of wood, coal, oil, natural gas, or candle wax.

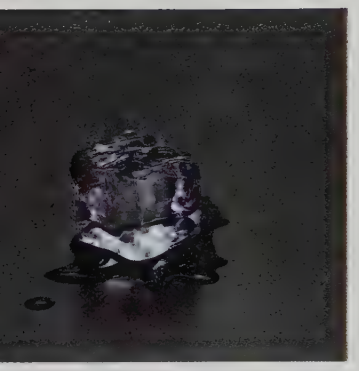
A teacher has just lit a candle with a match. What two fuels are burning? There is energy stored in the wooden match. When the wood burns it gives off energy. It gives off heat. It gives off light too.



When candle wax burns, it gives off energy. The energy in the candle wax changes. The energy stored in candle wax is called *chemical energy.* When any fuel burns, chemical energy is changed to light and heat.

chemical (kem'i·kəl)

Two Kinds of Changes

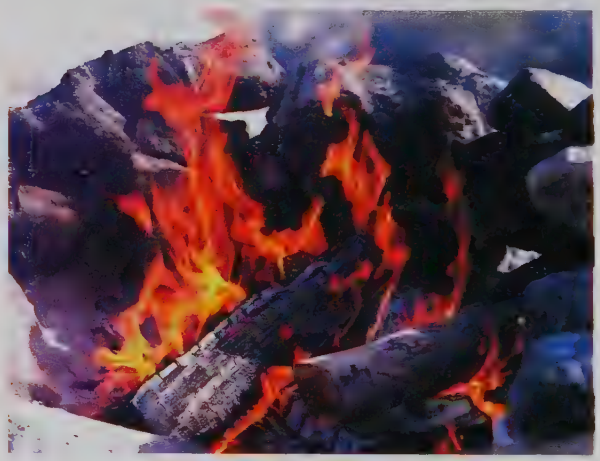


You know when water changes from one state to another, it is still water. Its molecules do not change.

When you break a piece of wood, you may change its size. You may also change its shape. But you still have wood. When you break a piece of coal, the smaller pieces are still coal. The molecules in the large and small pieces are still the same.

A change in which molecules stay the same is called a **physical change.** In a physical change, a substance changes in some ways. When you tear up a piece of paper, the paper is changed into smaller pieces. That is a physical change. The molecules of paper have not changed.

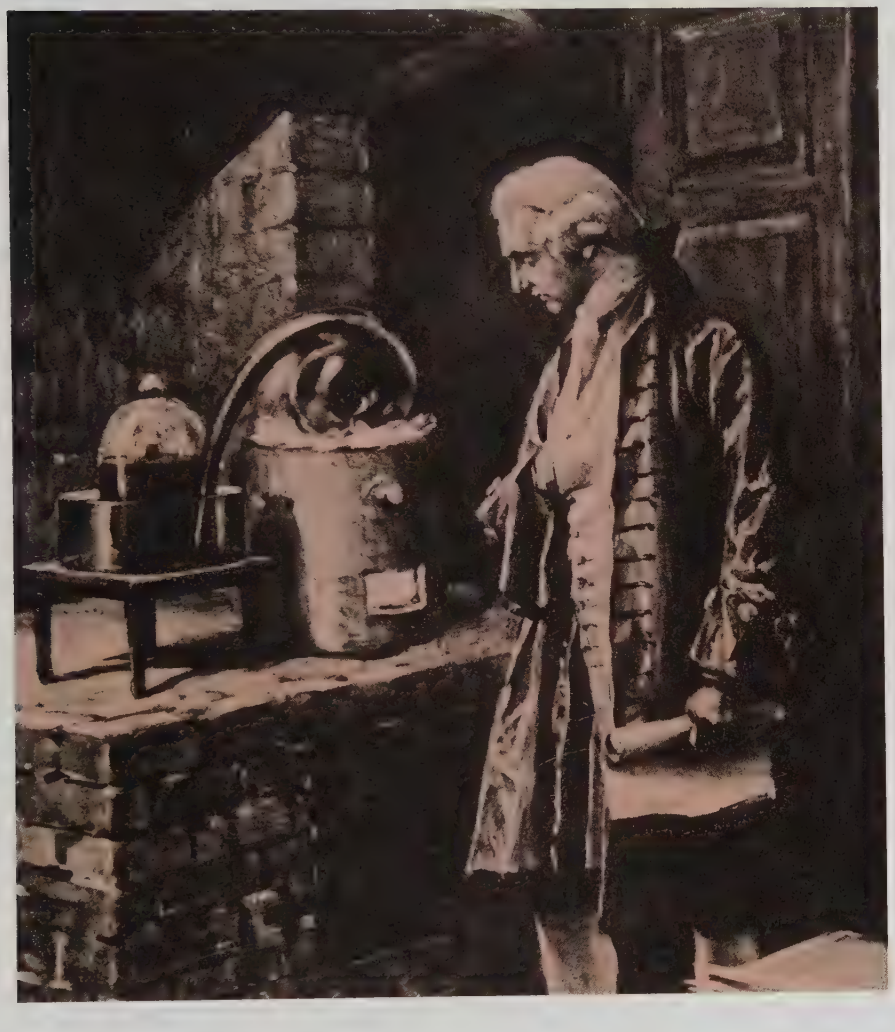
When wood burns, the molecules in the wood change. The wood changes to other substances. We no longer have molecules of wood.



We say burning is a **chemical change.** The burning of coal is a chemical change. So is the burning of paper. In a chemical change, the molecules of a substance change. They change into molecules of different substances.

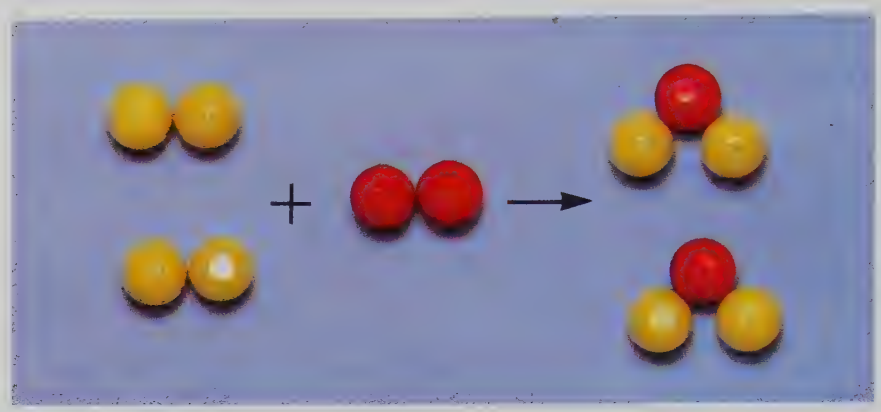
Let's look more closely at these changes. What happens to the molecules of any fuel when it burns?

Antoine Lavoisier was a French scientist. About 200 years ago, he studied the gases that make up air. He named one of the gases oxygen. You know people need oxygen to live. Lavoisier learned fuels need oxygen to burn.

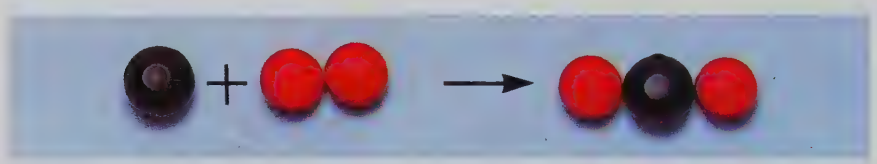


The fuel you know as natural gas is mainly methane. Here is a model of a molecule of methane. What two elements is methane made of? Observe that methane is made of carbon and hydrogen. When methane burns, its molecules break down. They combine with the oxygen in the air.

The hydrogen combines with some of the oxygen. Molecules of water are formed.



The carbon also combines with some of the oxygen. Molecules of carbon dioxide are formed.



When any fuel burns, molecules break down. Heat and light energy are given off. In burning, oxygen from the air combines with the fuel. Most fuels have both carbon and hydrogen. When the carbon burns, carbon dioxide is formed. When the hydrogen burns, water is formed.

Things You Know

1. Name four fuels. Where does the energy in each fuel come from?
2. What is the chemical energy of any fuel changed into when the fuel burns? Is this a chemical or a physical change?
3. What happens to molecules of methane and most other fuels when they burn?

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

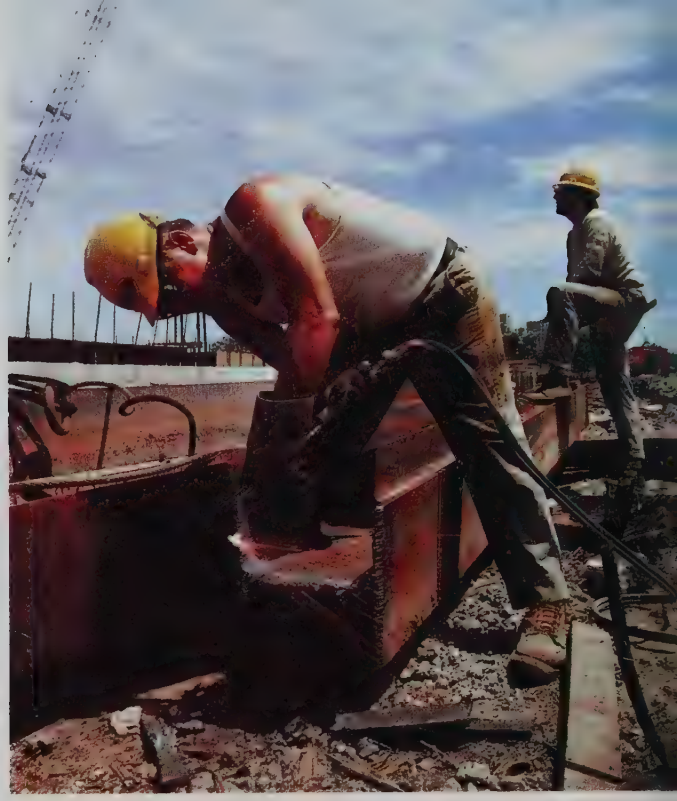
1. Work is done when a thing (moves, stops).
2. A force is a push or a (change, pull).
3. When a force is exerted, work is (always, sometimes) done.
4. To run, any machine needs (energy, muscles).
5. Falling water and moving air have (electricity, energy).
6. Coal, wood, oil, and natural gas are (fuels, machines).
7. Breaking wood is a (chemical, physical) change.
8. When a fuel burns, its molecules combine with (oxygen, hydrogen).
9. To exert a force, you use energy from (food, methane).
10. Whenever a fuel burns, chemical energy is changed to light and (work, heat).

B. Answer each question.

11. When methane burns, does a chemical change or a physical change take place? Explain.
12. Methane is a fuel made of carbon atoms and hydrogen atoms. What compounds are formed when methane burns?
13. Copy this model of a molecule of methane into your notebook. Then draw models of molecules to show what happens when methane burns.

14

Speeding Molecules at Work



Think about all the times you have seen work being done. Think about the force that was exerted. Each time, something supplied the energy for the force.

One man in the picture is using a torch to cut steel. The energy for the torch comes from fuel. Heat from fuels can supply the energy needed to do work. Let's see how.

A

Speeding Molecules

Imagine you have just come into the house after playing outdoors. You hear the cover of a pot rattle. You guess that something is cooking in a pot over a flame. You walk into the kitchen. You see the cover of the pot moving up and down. What could make a cover move?

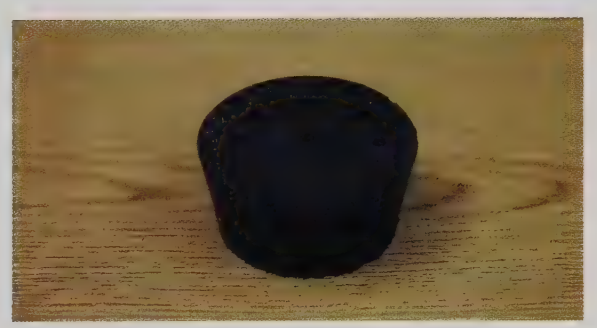
In these pictures, the dots stand for molecules of water. When you burn fuel to heat water the energy in the fuel is changed to heat. The heat makes the molecules of water speed up. As the water gets hotter, the molecules bump and bounce off one another. The molecules move farther apart.

If you add enough heat to liquid water, the water boils. The molecules spread out. The water expands. It becomes water vapor. In the air, the water vapor condenses to form steam.

The molecules in steam are moving very, very fast. Can these speeding molecules exert force against something? Why do you think so?

Finding Out:

Can steam do work?



Fill a Pyrex bottle halfway with water. Close the bottle tightly. Use a rubber stopper like this one. Be sure the stopper has three holes in it.

Put a metal pinwheel in the center hole of the rubber stopper. Then stand the bottle on a hot plate. Ask your teacher to turn on the hot plate. What happens to the pinwheel?

The water in the bottle boils. The water turns to steam. Can steam do work? How do you know?

As the steam gets hotter, its molecules move faster. The steam expands more and more. Does an expanding gas have energy? Why do you say so?

In an expanding gas, the molecules are moving very, very fast. The speeding molecules have a great deal of energy. These molecules can exert force against something in their way.

Things You Know

1. Describe what happens when heat speeds up molecules of water.
2. Why do the molecules in an expanding gas exert a force?
3. How could you show that steam can do work?

Finding Out in the Library: Geysers

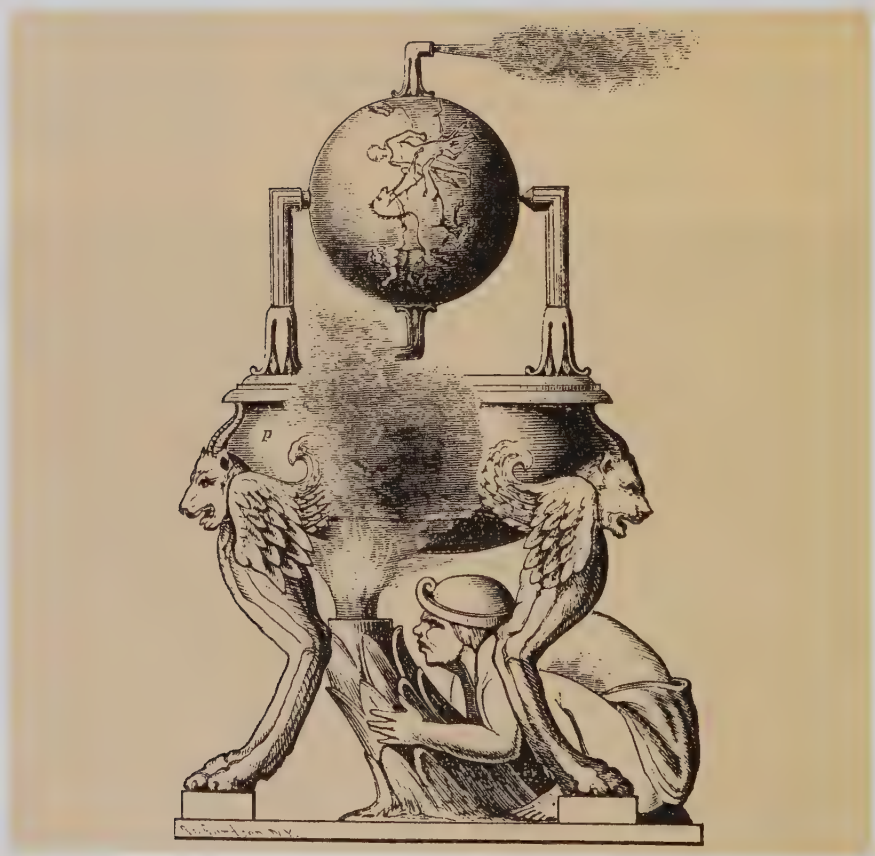
Have you ever heard of "Old Faithful"? Old Faithful is a geyser in Yellowstone National Park. In a geyser, water and steam shoot up from deep below the Earth's surface. Find out how the water gets so hot and what forces it out of the ground.

When a Gas Expands

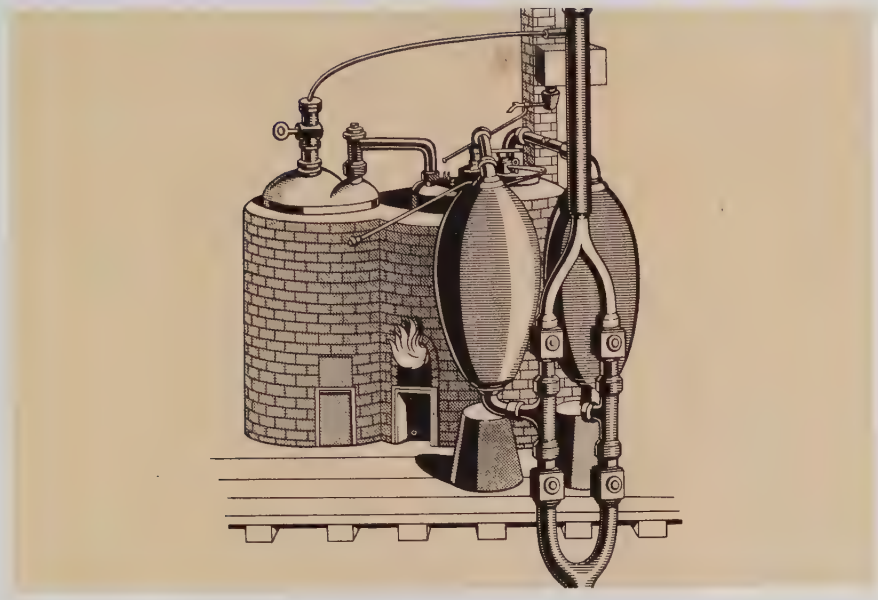
Surely the word *engine* is not new to you. An engine is a machine that uses a force to do work. A steam engine uses the force of an expanding gas from boiling water to do work. Doesn't the energy for the force come from a burning fuel?

A Greek inventor named Hero built this engine about 2000 years ago. Wood was used for fuel. From the picture, tell how the engine worked.

Hero probably built the first steam engine. But it did no useful work. It was almost 300 years ago, in England, when the force of steam was used to do work for the first time.

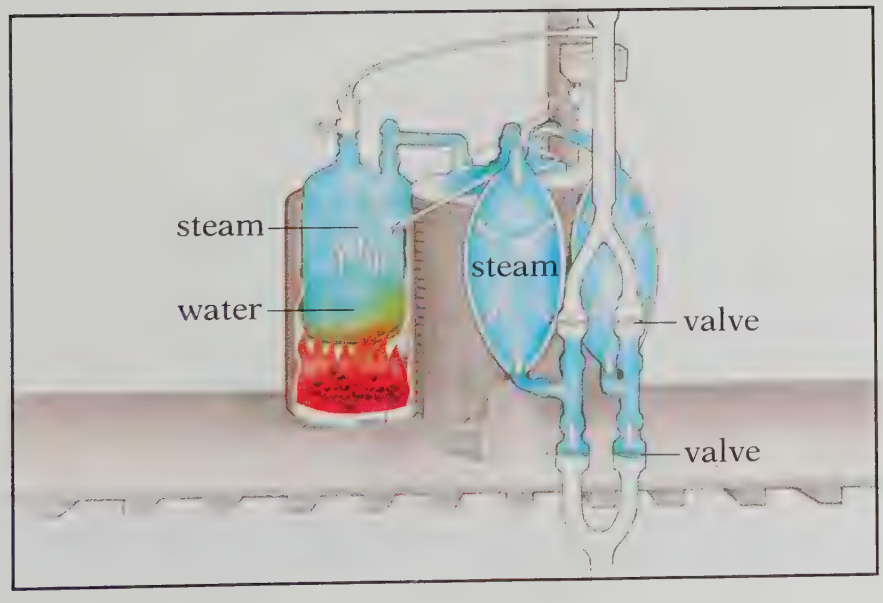


This engine was built by Thomas Savery. It used the force of steam to pump water from coal mines.



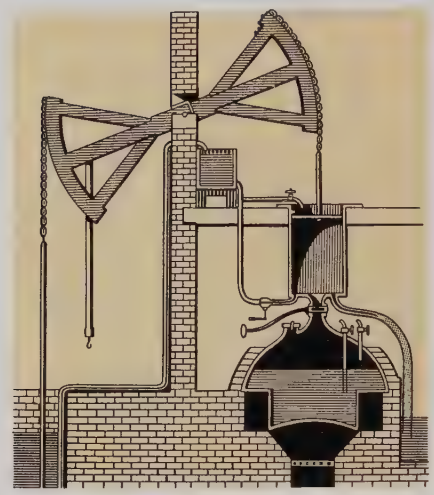
How is this engine an example of science and technology working together?

Inside the engine, coal was burned to heat water to make steam. *Valves,* which act like gates, were used to let steam and water in and out. But the valves on Savery's engine had to be turned by hand.



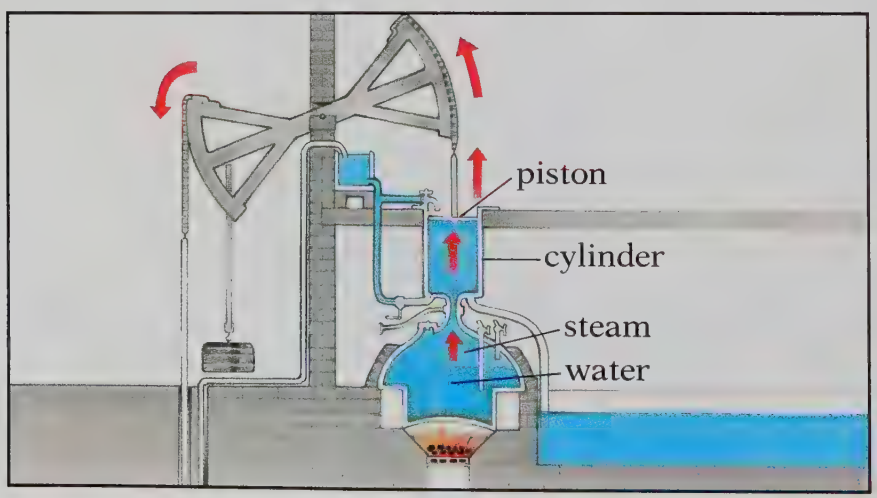
The Push of Steam

A few years later, Thomas Newcomen built this steam engine. It also used coal for fuel. But Newcomen's engine is different from Savery's engine.

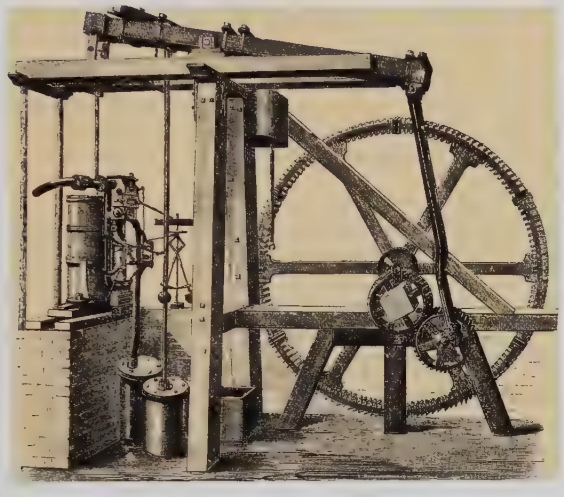


Look inside one part of Newcomen's engine. Find a kind of plug inside a tube. This plug is called a *piston.* The tube is called a *cylinder.* The force of steam moves the piston inside the cylinder.

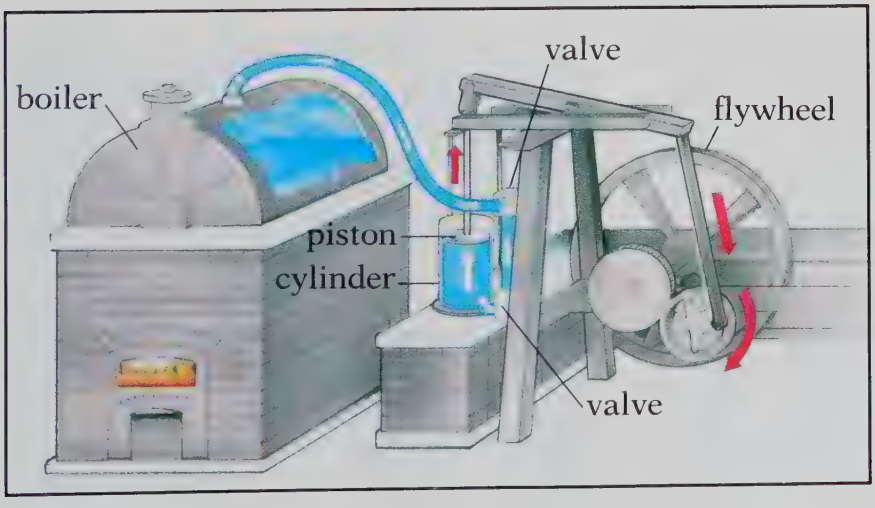
In Newcomen's engine, the piston moved up and down inside the cylinder. As the piston moved, water was pumped up from the mine.



Newcomen's engine was large and heavy. It was slow and used up a great deal of fuel. More than 50 years later, James Watt improved Newcomen's engine. Look at the picture of Watt's engine. Can you see one change that Watt made?



Like Newcomen's engine, Watt's engine used a piston inside a cylinder. But the piston was connected to a wheel. As steam pushed the piston, the wheel turned. Watt's engine was lighter and faster than Newcomen's engine. And it used less fuel.



Things You Know

1. What is an engine?
2. Describe Savery's steam engine. What was it used for?
3. Why was Watt's engine a better technology than Newcomen's?

Careers: In Transportation

In a great nation such as ours, we need many ways to get from place to place. People who work in transportation make sure that goods and other people travel quickly and safely.

Engineers design carriers, such as planes, cars, trucks, buses, trains, and ships, to carry goods and people. Drivers and technicians operate, service, and repair these carriers. Safety inspectors examine the carriers very carefully to be certain they are safe.

Some people load goods onto carriers. Other people help transport and take care of passengers. Perhaps you would like to help direct the flow of traffic–in the air or on the land.

Using Steam for Work

The first steam engines were used to move water. They moved water up from mines and deep wells.

Then Robert Fulton designed a steamboat. His steamboat used an engine much like Watt's steam engine. On its first trip, Fulton's steamboat carried passengers between Albany and New York City.

Before long, rails were built across the country. Great trains pulled by locomotives ran on these rails. What was the force behind the wheels on these locomotives? Steam, of course!

How are locomotives and the rails they run on examples of technology?

At first wood or coal was burned to make steam. Later oil was used for fuel. But it was the force of steam that moved the pistons that turned the wheels on these great trains.

Today, many engines still use the force of expanding gases. Not many engines use the energy of speeding molecules in steam. Hot, expanding gases from burning gasoline and oil may be used. The speeding molecules of these gases can also do work. Perhaps someone at home uses an engine that gets its energy from gasoline.

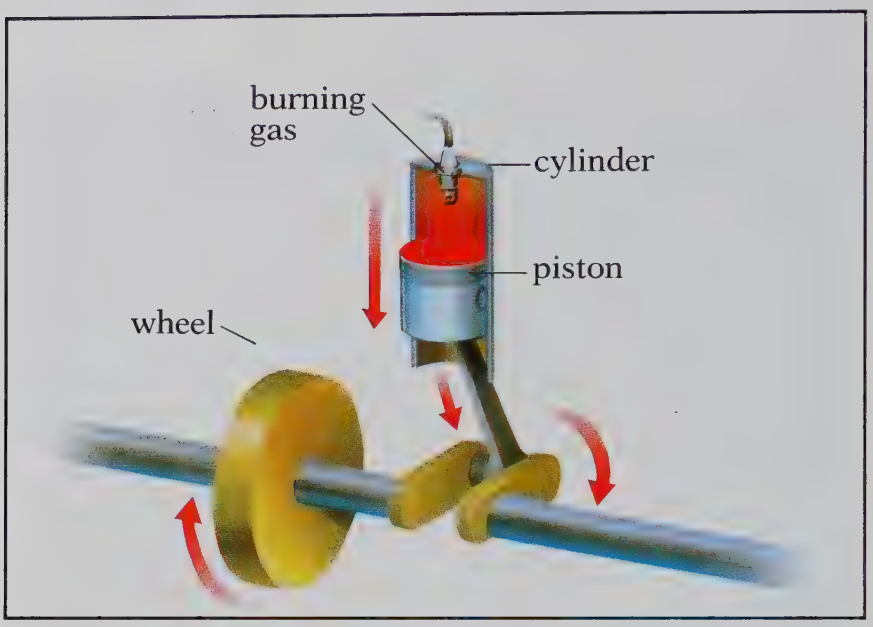
In this picture you see a kettle on a gas flame. The water in the kettle is hot. The water is boiling. Steam is coming from the spout. As the steam hits the pinwheel, the pinwheel turns. Simple. But let's find out what is really happening.

First, natural gas is burning. As it burns, it gives off energy. The chemical energy in the natural gas is changed to light and heat.

The heat makes the molecules of water inside the kettle move faster. The water is changed into steam. The steam exerts force on the pinwheel. It moves.

Whenever fuel is used to move wheels, energy is changed from one kind to another. Chemical energy is changed to heat. Heat speeds up the moving molecules. The force of the speeding molecules makes the wheels move. Work is done. Somewhat the same thing happens inside an automobile engine.

In an automobile, gasoline is changed into a gas. The gas burns. The burning gas moves a piston. The piston moves a wheel.



mechanical (mi·kän'i·kəl)

When something moves, we say it has *mechanical energy*. In most engines, chemical energy is changed into mechanical energy. Work is done.

Things You Know

1. What force was used to turn the wheels of early locomotives? What force is often used today?
2. How can you show that boiling water in a kettle does work?
3. Describe the changes that take place inside an automobile engine.

A Book For You:

Cars and How They Go explains some mysteries of the automobile engine and how it works. This book, by Joanna Cole, is published by Crowell, New York, 1983.

Using What You Know

A. Use terms from the list below to tell how expanding gases do work. Write the numbers 1 to 11 in your science notebook. Then write the correct term next to each number. You may use a term more than once.

chemical, coal, expanding gases, force, gas, gasoline, mechanical, oil, solar, water, wood, work

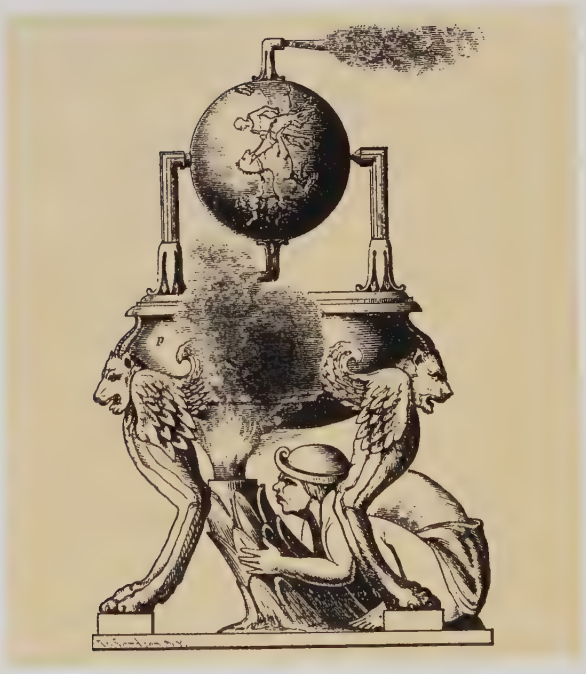
Steam can make things move. Scientists say that steam can do ___(1)___. The Savery and Newcomen steam engines used ___(2)___ as a fuel. The fuel was burned to heat ___(3)___ to make steam. A steam engine uses the force of ___(4)___ to do work.

Early railroad locomotives used coal or ___(5)___ as fuels to make steam. Today's locomotives use gasoline or ___(6)___. Steam engines use the ___(7)___ of expanding gases. So do ___(8)___ engines. In a gasoline engine, heat changes gasoline to a (an) ___(9)___ that moves a piston. Most engines change ___(10)___ energy from fuels into ___(11)___ energy.

B. Answer each question.

12. Does this engine do work? If it does, tell how.

13. Could this engine ever pull a train? Why do you say so?



Science and Technology:

Getting from Place to Place

First people used their feet to go from one place to another. Then they rode animals such as horses and donkeys. The wheel was a new and amazing technology. With the invention of the wheel, wagons and coaches became possible.

For a long time the wagon was a most important technology. Then we learned to use the energy of expanding steam. With steam came the technology of the steamboat, the locomotive, and the train. Then a way was found to make gasoline from oil. Hot, expanding gases from burning gasoline were used in new engines. Travel became much easier. Great towns and cities appeared across our country. Trucks, automobiles, and airplanes carried people and goods.

New fuels have been invented. Today, rockets use these fuels to carry satellites and people into space. What's next?

Push against a wall; it doesn't move. According to the scientist, no work is being done. You are exerting force, but that is all. Work is done only when a force makes something move.

To exert force, energy is needed. You lift a book. The book moves. You hit a ball. The ball moves. Where do you get the energy to exert force to move a book or a ball? Strangely enough, it comes from the matter you eat–from food.

The molecules in your food give you the energy to do work. The energy of moving molecules in fuel cooks your food. The energy of expanding gases in the engine of a car makes the wheels move. The energy of speeding molecules in rocket fuel shoots a rocket away from the Earth.

Whenever you find work being done, something is moving. Moving air and moving water have energy to do work. How can we use the energy of moving air and moving water?

You Know A Great Deal

A. Choose the term that makes each sentence correct. Then write the letter of the term you choose in your science notebook.

1. Coal and ice are
   a. gases b. liquids c. solids
2. Whenever molecules are heated they
   a. evaporate b. burn c. move faster
3. A push or pull is
   a. energy b. a force c. work
4. Coal, oil, and natural gas are
   a. elements b. fuels c. vapors
5. Molecules of different kinds of atoms join to form
   a. elements b. compounds c. mixtures
6. To do work, any steam engine uses the force of
   a. turning wheels b. expanding gases c. moving pistons
7. To burn, a fuel needs
   a. oxygen b. steam c. water
8. When water changes state from a liquid to a gas, the molecules of water
   a. move apart b. expand c. become atoms
9. An engine is a machine that uses a force to
   a. do work b. make energy c. burn fuel
10. The smallest part of water that is still water is
    a. a molecule b. an atom c. an element
11. In an automobile engine, gasoline is changed into
    a. a liquid b. a gas c. a solid

B. Do you do work when you pick up a pencil or push on a wall? Explain why.

A Project: Making Models of Molecules

You can use gumdrops to make models of molecules. You'll need four different colors of gumdrops to stand for atoms of different elements. Remember that red stands for oxygen, blue stands for nitrogen, yellow stands for hydrogen, and black stands for carbon. You'll also need toothpicks to join the atoms in your models together.

Make models of molecules of oxygen, nitrogen, and hydrogen. Look back in this book to review what these molecules look like.

Now make models of molecules of water, carbon dioxide, and methane. Remember each of these compounds contains two different kinds of atoms.

Ammonia gas is another compound. A molecule of ammonia gas contains one atom of nitrogen in the middle of three atoms of hydrogen. Make a model of a molecule of ammonia gas.

Books For You:

Watt Got You Started, Mr. Fulton, by Robert Quakenbush, published by Prentice-Hall, Englewood Cliffs, New Jersey, 1982. This book tells about the interesting discoveries of James Watt and Robert Fulton.

How to Be an Inventor, by Harvey Weiss, published by Crowell, New York, 1982. Do you want to find out how ideas for inventing things are formed and developed? Then read this book.

Wind Power, by Norman F. Smith, published by Coward, McCann, & Geoghegan, New York, 1981. With this book, you can explore the wind, its energy, and the history of wind power.

Food for Life

Both pictures show living things. In a way, they are all taking in food. What is the difference in the way they take in food? Perhaps you know that plants make their own food. People, of course, do not.

During the growing season, farmers plant seeds in the soil. Or seeds fall from plants growing in the meadows and forests. Or someone, perhaps you, plants seeds in a garden or in a pot of soil.

The seed sprouts. A tiny plant pokes its way out of the soil. The tiny plant grows a bit, using

Unit 5

the food stored in the seed. The young plant needs matter and energy to keep growing. Where does the plant get the matter and energy it needs?

You also need matter to keep growing. You call this matter by a simple name–food. Your food gives you the energy you need to keep growing. Where do you get energy for work and play?

We know a scientist who told us about *a terrible dream* he had. He dreamed that all the green plants on planet Earth had turned white. Why did he call this *a terrible dream?*

15

Growing Green Plants

You've probably eaten many different kinds of seeds. Beans, peas, and corn are seeds. So are nuts, such as acorns. You know apples and oranges have seeds. But you probably don't know that some pine cones have seeds. Perhaps you've puffed on a dandelion and blown some of the seeds away. What may have happened to the seeds?

A
Sprouting Seeds

You know that seeds can grow. But can pebbles grow? Of course not! Pebbles are not alive. Seeds can sprout into green plants–if the seeds get the things they need. What do seeds need to sprout?

Have you ever tried to grow plants from seeds? Here's a way to find out what happens.

Soak 8 bean seeds in water overnight. Then make two seed sprouters. Put a wet paper towel in each plastic bag. Put 4 seeds on each towel. Then close the plastic bag.

Cover one sprouter with shiny foil. Do not cover the other one. Put both sprouters in light. But don't let them get hot. Which seeds will get light? Which seeds will not?

The seeds need water to sprout. Be sure to keep the paper towels wet.

Observe the seeds every day to see which seeds sprout. Did your seeds need light to sprout? How do you know?

Roots, Stems, and Leaves

This bean seed was sprouted in soil. The seed got water. The seed did not need light to sprout.

A bean plant grew from the seed. Find the *roots.* Find the *stem* and *leaves.*

Will a bean plant grow turned on its side? A class wanted to find out. They filled two glasses with soil. They put bean seeds in each glass. They watered the soil. Then they carefully turned one glass on its side.

After a few days, the seeds sprouted. Which way did the roots grow? Which way did the leaves grow?

Next time you see a tree, look for its roots. Look for its leaves. Notice the roots grow down into the soil. The leaves grow up into the light and the air.

Look at other green plants. Which way do their roots and leaves grow?

Things You Know

1. What three parts of a plant grow from a seed?
2. How can you show if seeds need light to grow?
3. Which way do the roots of a bean plant or a tree grow? Which way do the leaves grow?

B

What Green Plants Need

Green plants are living things. You know that living things grow. What do green plants need to grow?

You learned plants don't grow well in sand. Plants grow better in soil. Remember that minerals are dissolved in soil water. Plants need minerals to grow well. Plants get these minerals from soil water, of course. A plant takes in soil, water, and minerals through its roots.

These two plants have just sprouted. They have good soil and enough water. But they still need something else. Let's find out what it is.

Soak 12 corn seeds in water overnight. Fill four pots with soil. Plant 3 seeds in each pot.

Put the pots in a dark closet. Keep the soil moist. Be sure it's not too wet.

As soon as the seeds sprout, put two of the pots near a sunny window. Leave the other two pots in the dark. Look at the plants each day.

The leaves of the plants growing in the light are green.

Observe that the leaves of the plants growing in the dark are not green. What do you think makes the difference? Don't green plants need light to grow?

Growing Plants from Seeds

You've sprouted bean seeds and corn seeds. Perhaps you'll want to sprout other kinds of seeds. To sprout, seeds need several things.

Seeds need good soil. The soil has the minerals plants need. Seeds need water. But not too much water. With too much water, the seeds will not get enough air. The seeds should not be too hot or too cold.

To grow well young plants need water. They also need minerals and light.

Things You Know

1. What do seeds need to sprout?
2. How do young plants get the minerals they need to grow?
3. How can you show that green plants need light to grow?

Oxygen and Light

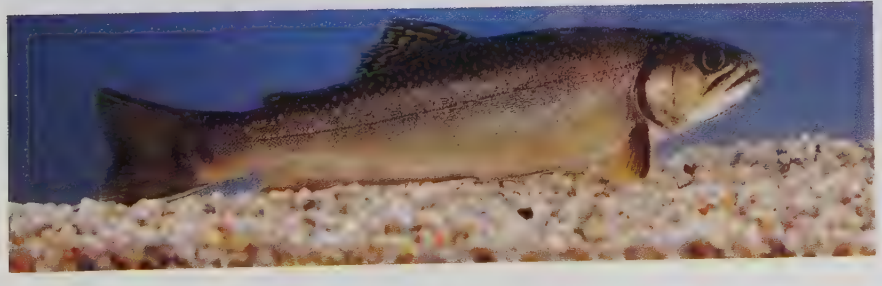
You breathe in. You breathe out. Count how many times you breathe in and out in one minute.

Ask a friend with a watch to keep time for you. You do the counting. Your friend can tell you when to start, and when to stop. How many times did you breathe in and out in one minute?

When you breathe in air, you take in oxygen. Your body needs oxygen to work. Living things need oxygen. Without oxygen, living things would die.

A fish doesn't get its oxygen from the air, the way you do. A fish gets its oxygen from the water it lives in. The oxygen is dissolved in the water. Let's see where the dissolved oxygen comes from.

What does dissolved mean? Turn to page 37 if you need to review.



Green Plants in an Aquarium

Some pupils decided to set up an aquarium. They filled it with pond water. They also put in a green plant called *Elodea. Elodea* is a plant that grows in water.

They placed a funnel over some of the *Elodea.* They put the aquarium where it would get good light. They also made sure the aquarium would not get too warm.

Soon they observed tiny bubbles of gas inside the funnel. The gas was given off by the *Elodea* plants. The gas was oxygen.

Much of the dissolved oxygen in water comes from green water plants. You know green plants need light to grow. Do green plants also need light to make oxygen? Here's what the pupils found out.

The pupils took their aquarium, with the *Elodea* plants, out of the light. They observed the *Elodea* under the funnel. There were no bubbles. The class watched and waited, but there were no more bubbles. They thought that green plants make oxygen only in the light.

Green plants must have light to make oxygen. Living things depend on green plants for the oxygen they need. Much of the oxygen we use comes from green plants in the oceans of the world.

Things You Know

1. Where do you get the oxygen your body needs? Where does a fish get oxygen?
2. Why do living things depend on green plants?
3. Do green plants need light to make oxygen? Why do you say so?

Chapter 15

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. The part of the tree that grows in the soil is the (root, stem).
2. To sprout, seeds do *not* need (water, light).
3. To grow, green plants need water and (light, darkness).
4. Green plants get minerals from (the air, soil water).
5. Living things depend on green plants for (oxygen, water).
6. Most plants grow best in (sand, soil).
7. To sprout, seeds should be (very cold, fairly warm).
8. Plants take in water through their (roots, leaves).
9. In sunlight, green plants give off (hydrogen, oxygen).
10. One kind of seed is (a bean, Elodea).

B. Bean seeds are planted in each glass. In your notebook draw the way the roots, stems, and leaves grow after a few days. Label the roots, stems, and leaves.

16

Green Plants Make Food

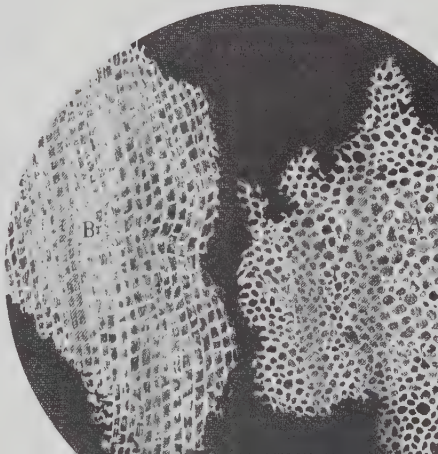
You know plants have roots, stems, and leaves. Did you know that roots, stems, and leaves are made of **cells?**

More than 300 years ago, Robert Hooke used what was then a new technology. Hooke used a microscope to look at cells.

A

What Makes Plants Green?

Hooke looked at a thin slice from a cork tree. He drew what he saw. Hooke saw little boxes. He called them cells. Find the cells in Hooke's drawing.



Hooke learned that the bark of cork trees was made of cells. Scientists now know that *all* living things are made of cells. You too can use a microscope to look at cells.

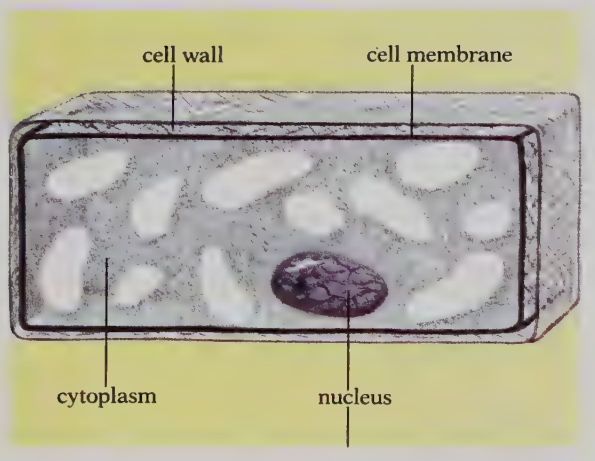
Suppose you use a microscope to look at a root cell. What might you see?

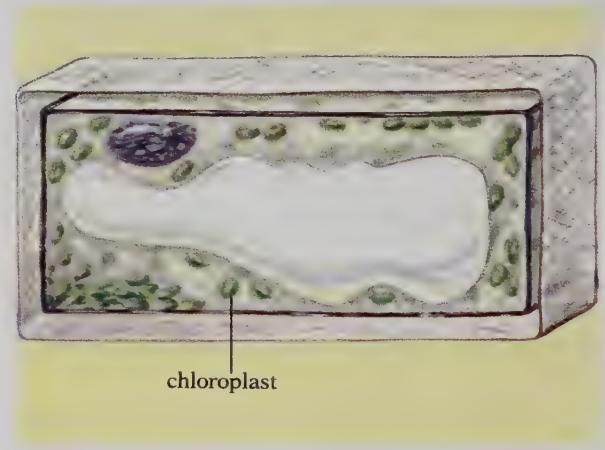
At the left is a cell from a thin slice of an onion root. Look for the **cell wall.** The cell wall covers the outside of the cell.

Just inside the cell wall is the **cell membrane.** Observe in the picture that the cell membrane is very, very thin.

Now look for a large, dark spot inside the cell. This spot is the **nucleus.** There is a nucleus in almost every cell. Between the nucleus and the cell wall is the **cytoplasm.** The cytoplasm looks fairly clear. You may find some empty spaces in it.

cytoplasm
(sīt'ə·plaz·əm)





The other picture shows a cell from the leaf of a green plant. Find the nucleus of the cell. Now find the cell wall and the cell membrane. Where is the cytoplasm?

The leaf cell is different from the root cell in one important way. In the leaf cell, look at the small, green bodies that are shaped like footballs. These green bodies are the **chloroplasts.** There are no chloroplasts in root cells.

chloroplast
(klōr'ə·plast)

Chlorophyll

Green leaves have chloroplasts inside their cells. There is a green compound inside a chloroplast. This compound is called **chlorophyll**. Chlorophyll makes the leaves green.

chlorophyll
(klor'ə·fil)

What elements make up the compound chlorophyll? Where can you find out?

Some people think chlorophyll is one of the most important of all compounds. Why is chlorophyll so important? You will study this next.

Things You Know

1. What is one way all living things are alike?
2. What makes the leaves of plants green?
3. How are the parts of a leaf cell different from the parts of a root cell?

B

Where Green Plants Make Food

This is one kind of geranium plant. Chlorophyll makes its leaves green.

Now look at the leaves on another kind of geranium plant, a silver-edged geranium. The edges of the leaves look white or silver in color. The centers of the leaves are green.

Suppose you looked at cells of these leaves through a microscope. Would you find cells with chloroplasts at the edge or in the center? Why?

The green chlorophyll was removed from a leaf of a silver-edged geranium plant. The color of the leaf changed, as you see in the photograph.

Look what happened when iodine was put on the leaf. Part of the leaf turned blue-black. Let's see why.

Iodine can be used to test for starch. Where there is starch, iodine turns blue-black. The part of the leaf that was green turned blue-black. So there was starch only in the green part of the geranium leaf.

The chloroplasts in the leaves of green plants can make starch. Green plants usually make sugars first. Then the sugars are made into starch. But for now, it is enough to know chloroplasts can make starch.

Green Plants Make Starch

You've probably eaten peas. Surely you've eaten green beans, potatoes, or corn. Then you've eaten *starch.* Starch is a kind of food. Starch is made by green plants.

A student put a drop of iodine on a piece of potato. Doesn't the potato have starch in it?

Green plants do something that is very important. They make their own food. Animals can't make their own food. Of course, we can't either.

Green Plants Need Energy

We must grow green plants, like these corn plants, for food. The fruits, vegetables, and breads we eat come from green plants. We must grow green plants to feed animals. The animals we use for food eat green plants. We could not live without green plants.

Green plants get energy from the food they make. But making food takes energy.

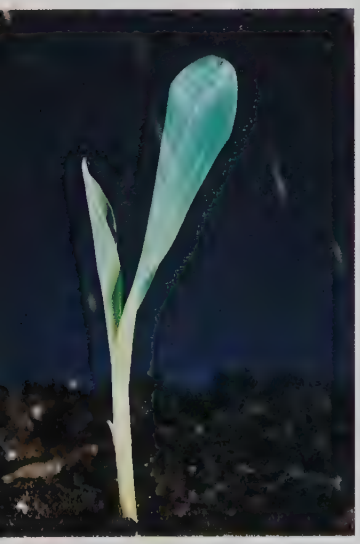
You probably know where green plants get energy. The energy comes from the Sun. Green plants use the Sun's energy to make food. They use it to make oxygen as well.

But green plants can't use the Sun's energy without chlorophyll. That's why chlorophyll is one of the most important compounds in the world.

Things You Know

1. Why is starch found only in the green part of a leaf from a silver-edged geranium?
2. Could people live without green plants? Why do you say so?
3. Why is chlorophyll such an important compound?

Storing Food in Green Plants



You need energy to work and play. You need energy to grow. You get the energy you need from food.

This young corn plant needs energy. It needs energy to grow. The young corn plant also gets its energy from food.

Many plants store food in seeds. A corn seed has food stored in it. As a corn seed sprouts, the young plant uses the food stored in the seed. The food gives the young plant energy to grow leaves. Once the young plant has green leaves, the plant can make its own food.

Young plants get energy from the food stored in seeds. You get energy from many different kinds of seeds when you eat them.

You know green plants can store food in their leaves. You eat leaves of plants when you eat lettuce or spinach.

Beet, carrot, and turnip plants store food in their roots. Name other roots of plants you eat.

Where else do plants store food? Some plants store food in their stems. You may not know a white potato is an underground stem. Perhaps you had thought a white potato is a root, just like a sweet potato.

Sugarcane plants also store food in their stems. Some table sugar is made from the food stored by sugarcane plants.

Green plants may store food in fruits. Fruits that taste sweet have sugar stored in them. Name some fruits you like to eat.

The white cauliflower is an unopened flower. So is broccoli. Broccoli and cauliflower plants store food in their flowers. Perhaps you have eaten these flowers.

Things You Know

1. Where does a young plant get energy before it has green leaves? After it has green leaves?
2. Why must you eat fruits and vegetables?
3. Green plants store food in leaves, roots, stems, and flowers. Which part of a plant is each of these: beet, spinach, apple, white potato, carrot, tomato, lettuce, orange?

A Project : Observing Bean Seeds

Soak a few lima bean seeds overnight. Take one seed and gently remove the thin layer that covers the seed. This layer is called the seed coat.

Carefully separate the two halves of the lima bean seed. Examine each half with a magnifying glass. Do you notice a very small bean plant? If you look closely, you'll find a root and two tiny leaves. A new bean plant would grow from this very small plant. What happens to the two halves of the seed as a new plant grows?

You might also examine peas, peanuts, and soybean seeds. Compare these seeds with lima bean seeds. Draw pictures of what you observe.

Using What You Know

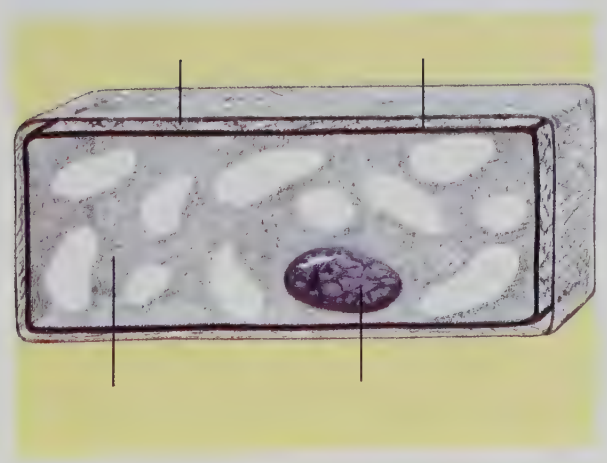
Write the answers to all questions in your science notebook.

A. Read each sentence. Use terms from the list below to fill in the blank spaces. Do not use a term more than once.

chlorophyll, chloroplasts, flowers, fruits, iodine, roots, seeds, starch, stems, sugars, Sun, white potato

1. The green compound in plants is _____.
2. The edges of a silver-edged geranium have no _____.
3. Before green plants make starch they make _____.
4. To show that a potato has starch, add a drop of _____.
5. Chloroplasts in a plant leaf make _____.
6. The energy green plants need to grow comes from the _____.
7. Very young plants get energy from food stored in _____.
8. Beets and carrots store food in their _____.
9. An underground stem that stores food is the _____.
10. Broccoli and cauliflower store food in their _____.

B. Which is a root cell and which is a leaf cell? Label the parts of each cell.



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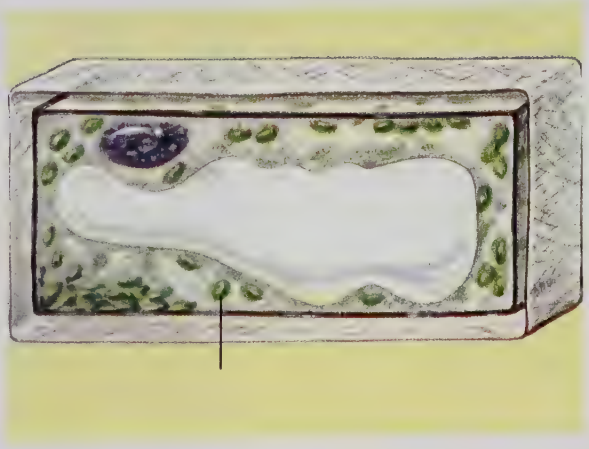


b.

17

Food for Growth

Of course you like some foods better than others. Yet you probably know that some foods are better for you than others. Let's find out which foods help your body grow best.

A

Groups of Foods

As you read on, you'll learn many new things about foods. How many kinds of food are there? Scientists classify foods into five groups. The first four are the *Milk Group,* the *Meat Group,* the *Fruit and Vegetable Group,* and the *Bread and Cereal Group.*

Foods in the Milk Group are made from milk, of course. You probably know milk comes from dairy cows. That's why the Milk Group is sometimes called the Dairy Group.

Milk Group

Beef, eggs, chicken, lamb, pork, and fish are in the Meat Group. These foods all come from animals. You may be surprised to learn that some food plants are in the Meat Group. Peas, beans, and nuts belong in this group. You'll soon learn why.

Meat Group

Fruit and Vegetable Group

Of course, foods in the Fruit and Vegetable Group come from plants. Foods in the Bread and Cereal Group are made from plants called grains. Wheat, corn, rice, and oats are grains.

Bread and Cereal Group

People must eat foods from these four food groups to stay healthy. Be sure you eat foods from these four groups each day.

Fats and Sweets Group

The fifth group is the *Fats and Sweets Group.* Cake, candy, soda pop, and jelly are in this group. Butter and margarine are also in the Fats and Sweets Group. But you don't have to choose foods from this group. You can get sugar and fat from foods in the first four groups.

Things You Know

1. What foods are included in each of the five food groups?
2. Name four foods in each of the five food groups.
3. Suppose you have a tuna sandwich and a glass of milk for lunch. Does your lunch include foods from the first four food groups? Why?

B

Nutrients You Need

Make a list of the foods you eat during one week. The list shows your *diet* for that week. All the foods you eat and drink make up your diet. A good diet includes foods from the first four food groups. But that's not all.

nutrient (nü'trē·ənt)

Foods have **nutrients** in them. Nutrients are substances your body needs to grow and stay healthy. A good diet gives you the nutrients you need.

Scientists who study food and diet are called *nutritionists.* Nutritionists say you need six different nutrients to stay well. Let's start by studying four of these nutrients.

CARBOHYDRATES: Most of the foods made by green plants are rich in sugars and starches. Sugars and starches are **carbohydrates.**

Your body gets most of the energy it needs from carbohydrates. What foods do you eat that are rich in carbohydrates?

carbohydrate (cär·bo·hī′drāt)

PROTEINS: You know beef, chicken, pork, and fish come from animals. These foods are rich in **proteins.** You also get proteins from eggs and dairy foods.

protein (prō′tēn)

Your body also gets some energy from proteins. Your body uses proteins mainly to grow and to repair itself.

Beans, soybeans, peas, and nuts are all seeds made by green plants. These seeds are rich in proteins. That's why nutritionists put these seeds in the Meat Group.

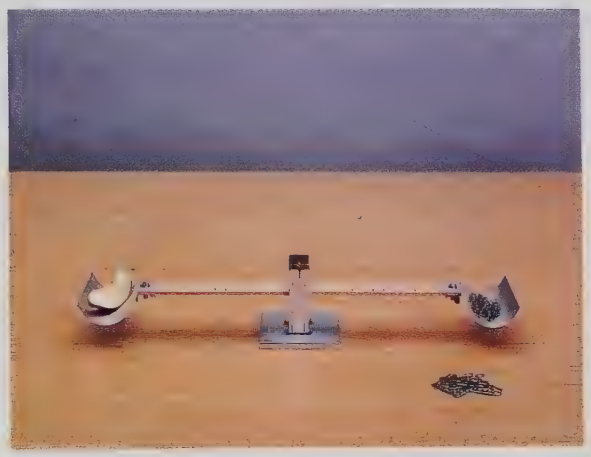
FATS: Your body gets energy from **fats.** Foods rich in protein usually have some fat. You may have seen fat on meat or chicken. Dairy foods have fat in them too.

Oil is a kind of fat. We get oils from the seeds of many plants.

WATER: Your body needs **water.** Surely you drink water when you are thirsty. You are drinking water when you drink milk or juice. There's water in vegetables and fruits too.

In your body, water weighs more than all the other nutrients together.

Perhaps your teacher will cut an apple into slices. You may see water coming out of the apple. Do the slices look wet? Do they feel wet?



Put a slice on one side of a simple balance. Put paper clips on the other side. Find out how many paper clips you need to balance the apple slice.

Put the slice in a sunny, dry place. Leave it out overnight. Or ask your teacher to warm the slice on a hot plate for an hour. Does the slice feel drier than it did before?

Use paper clips to balance the apple slice again. How many paper clips do you need now? Water must have evaporated from the slice. What evidence do you have?

More than Four

Your body needs carbohydrates, proteins, fats, and water. But you could not live on these four nutrients alone. Your body also needs **minerals** and **vitamins.** You also get these nutrients from foods you eat.

Things You Know

1. What are the six nutrients in food?
2. Name four foods that are rich in each of these: proteins, fats, carbohydrates.
3. How can you show that a pear has water in it?

A Project: Testing Foods for Fat

How can you find out if a food has fat in it? You might place a drop of liquid fat on a piece of brown paper. Then hold the paper up to the light. Does light come through the spot where the fat is?

Leave the paper for a few hours. Does the spot dry or does it stay the same?

Now test some peanut butter for fat. Rub some peanut butter on a piece of brown paper. Then scrape off the peanut butter. Is there fat in peanut butter? What evidence do you have?

Try testing other foods, such as nuts, olives, and milk, for fat. What do you find out?

Minerals in Your Diet

You know bones and teeth are hard. A compound called calcium phosphate makes them hard. Calcium phosphate is made up of two minerals–calcium and phosphorus. Your body uses calcium and phosphorus to make your bones and your teeth.

Your body also uses these minerals in other ways. For example, your muscles need calcium to do their work.

You need calcium and phosphorus in your diet. You get these minerals from foods. The water in foods has minerals dissolved in it.

Milk and other dairy foods are good sources of calcium and phosphorus. So are many fruits and vegetables. Eggs and leafy green vegetables have some calcium. You can get phosphorus from meats, chicken, fish, grains, and nuts.

Iron

Iron is another mineral you need. You need iron in your blood. Iron in your blood combines with protein to form a compound that makes blood red. This compound carries the oxygen you need to live. While you are reading this, your blood is carrying oxygen to all parts of your body.

anemia (ə·nē'mē·ə)

Some people have a disease called *anemia.* They don't have enough iron in their blood. People with anemia get tired easily. Their blood can't carry enough oxygen.

Liver and other meats are good sources of iron. So are beans, peas, grains, and leafy vegetables. Be sure you get enough iron in your diet. A doctor can tell if you do by examining your blood.

Just a Pinch

You need small amounts of other minerals–just a tiny pinch. Yet you must have these minerals to stay in good health. You need tiny amounts of magnesium, copper, potassium, and sulfur. You also need a little sodium and a little zinc.

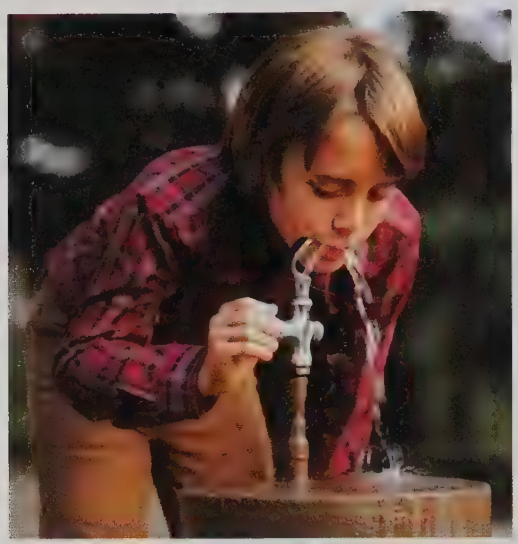
By the way, plants need these minerals too. For example, magnesium is part of the green compound chlorophyll. You know that plants use minerals that are dissolved in soil water. How do you get your minerals?

You get the mineral iodine from fish and other seafoods. Sometimes iodine is added to table salt. Table salt is the compound sodium chloride. So you may get two minerals from table salt–iodine and sodium.

You don't have to shake salt on your food. You can get the minerals in salt from the different foods you eat.

Minerals in Water

We get several minerals from our drinking water. The minerals listed in the table are probably in the water you drink. Which of these minerals are also found in food?



Some Minerals in Water
sulfur
chlorine
sodium
calcium
magnesium
potassium
fluorine

Things You Know

1. Name a food that is a good source of each of these minerals: calcium, phosphorus, iron, sodium, iodine.
2. We eat plants for some minerals. How do plants get these minerals?
3. Why do you need iron in your diet?

A Book for You:

Would you like to learn more about different kinds of foods and why they are needed? Would you also like to find out about what would happen to your body if you did not eat various foods? Then read the book: *Nutrition,* by Paul Thompson, published by Watts, New York, 1981.

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. A mineral your body needs for strong bones is (calcium, iodine).
2. A nutrient your body uses mainly for energy is (protein, carbohydrate).
3. The water you drink is a good source of (minerals, fats).
4. Most foods that are rich in protein are in the (Bread and Cereal Group, Meat Group).
5. The mineral your body uses for good red blood is (magnesium, iron).
6. For a good diet, you should get the sugar you need from the (Fats and Sweets Group, other four food groups).

B. Copy the list of food groups. Then put each food below in the correct food group.

bananas, beans, beef, cheese, corn, ice cream, jelly, margarine, noodles, rolls

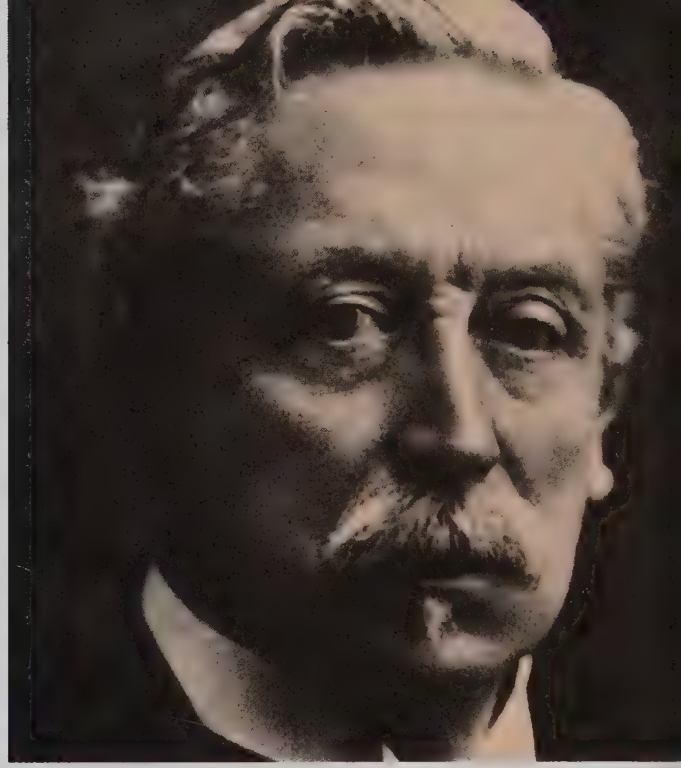
Milk Group: _____, _____
Meat Group: _____, _____
Fruit and Vegetable Group: _____, _____
Bread and Cereal Group: _____, _____
Fats and Sweets Group: _____, _____

C. List the six kinds of nutrients. Then tell the main kinds of nutrients, except vitamins, that are found in each of these foods:

bread	eggs
margarine	lettuce
spaghetti	fish
peas	orange juice
hamburger	cheese
watermelon	chocolate cake

18

The Need for Vitamins



You know that your body needs vitamins to grow strong and stay healthy. How did we learn we need vitamins?

The story begins with Christiaan Eijkman, a Dutch doctor working in Java. Java is an island in the southwestern part of the Pacific Ocean.

A

Thiamine and Niacin

Dr. Eijkman saw people who couldn't use their muscles. They could hardly walk. The people were too tired and weak to work. These people had a disease called *beriberi.* The name tells you something about the disease. The word beriberi means "I can't."

The people with beriberi had enough to eat. Dr. Eijkman wondered what was making them sick.

Eijkman's Experiment

One day, Dr. Eijkman observed some chickens eating white rice. The chickens looked sick. They looked like they had beriberi.

A few weeks later, the chickens looked healthy again. The chickens' diets had changed. They were now eating brown rice. What is the difference between the two kinds of rice?

A grain of rice has a tight brown covering around it. Brown rice is rice with the covering left on. White rice is rice with the brown covering rubbed off.

Dr. Eijkman knew that most of the people living in Java ate rice. Now he thought he knew what caused beriberi. He planned an experiment to test his idea. But he used chickens in his experiment, not people.

Dr. Eijkman divided his chickens into two groups. He fed white rice to one group. He fed the other group brown rice. He kept everything else the same for both groups of chickens.

One group of chickens got beriberi. It was the group that ate white rice. The chickens that ate brown rice stayed healthy.

Thiamine

Some of the people living in Java ate only white rice. These people often got beriberi. Now Dr. Eijkman knew why.

Many people ate brown rice. These people didn't get beriberi. Dr. Eijkman knew that something in the brown covering kept people healthy.

Today scientists know there is *thiamine* in brown rice. Thiamine is a vitamin. We get thiamine from whole grains. Whole grains are grains with the covering left on. Brown rice and whole wheat are whole grains. White rice, of course, is not a whole grain.

We can also get thiamine from peanut butter, and from seeds like peas, beans, and nuts. Think how you get thiamine in your diet.

The Work of Dr. Goldberger

Where he worked, Dr. Joseph Goldberger saw some sick children. These children had rough, red patches on their skin. The children had a disease called *pellagra.* Pellagra made them weak and tired.

The children were not hungry. They ate plenty of foods–made from corn. But they did not get much meat, milk, eggs, peas, or beans. Dr. Goldberger wondered if corn gave the children all the nutrients they needed. Perhaps something was missing from their diets.

Dr. Goldberger wanted to find out. Twelve men took part in an experiment. He put these men on a special diet. He gave them plenty of foods made from corn and other starchy vegetables. But they had no meat, milk, eggs, peas, or beans. After six months, five of the men had pellagra.

Other men ate the same starchy foods. But they also ate foods rich in protein, like meat and milk. None of these men got pellagra. What made the difference?

Niacin

Niacin is one of the vitamins that prevents pellagra. You need niacin to stay well.

You get niacin by eating foods rich in protein, such as fresh meats, chicken, or fish. You can also get niacin by eating several kinds of seeds. You know peas, beans, grains, and nuts are seeds. Which of these foods do you eat?

Things You Know

1. What vitamin is in the covering of whole grains? What other foods are a good source of this vitamin?
2. Why is niacin important to your diet? What foods are good sources of niacin?
3. Dr. Eijkman did an experiment with chickens to find out what caused beriberi. Describe his experiment.

Vitamin C

Long ago, sailors sometimes spent months at sea in sailing ships. The ships didn't have refrigerators. Fresh fruits and vegetables spoiled quickly. Much of the time sailors ate salted meat, dry bread, and water.

Sailors on this diet didn't stay healthy. Many got a disease called *scurvy*. People with scurvy heal slowly and often have sore gums. Doctors tried to cure scurvy by feeding sailors vinegar or garlic. But these foods didn't cure the disease.

Dr. James Lind worked on a sailing ship. He thought oranges and lemons could cure scurvy. He asked sailors with scurvy to help him test his idea.

Dr. Lind's Discovery

Some of the sailors ate oranges and lemons. Some drank vinegar. Some ate garlic. What did Dr. Lind find out?

The sailors who ate oranges and lemons got well quickly. The other sailors stayed sick. Now Dr. Lind knew what made the difference. Something was missing from the diet of the sailors who were sick.

Today we know why the sailors got scurvy. *Vitamin C* was missing from their diets.

Oranges, lemons, limes, and grapefruit are citrus fruits. Citrus fruits are good sources of vitamin C. So are many other fruits and fresh vegetables.

Your body uses vitamin C every day. But your body cannot store this vitamin. That's why you need citrus fruits or juice in your diet every day. You should also eat other foods rich in vitamin C.

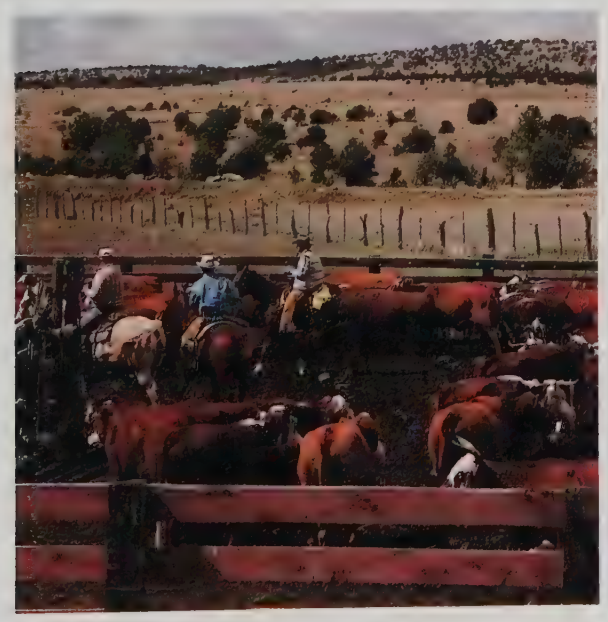
1. How did Dr. Lind cure sailors who had scurvy?
2. What vitamin prevents scurvy?
3. Name foods that are good sources of this vitamin.

Careers: In Farming and Ranching

Farms and ranches produce most of the food we eat. Ranchers may raise chickens, turkeys, sheep, or cattle. Many ranchers also grow the grain they feed their animals.

On large farms, machines that can plow fields, plant seeds, and even pick crops are used. On smaller farms, some of this work is done by hand.

Some people do research in developing new kinds of plants and animals. Other people sell, service, and repair machines and equipment used on farms. Still other people help deliver or sell farm products. If you don't live on a farm or ranch, perhaps you can visit one near your home.



C

Other Vitamins

Your body needs many different vitamins. You've studied only a few of them. Thiamine and niacin are *B vitamins.* You know you need thiamine and niacin to stay well. But there are many other B vitamins. And your body needs a little bit of each one.

Your body also needs *vitamin D.* Without vitamin D, your body cannot use the calcium in your diet. You know your body needs calcium to make bones hard. So your body needs vitamin D to build strong bones.

Animals need vitamin D too. One of these dogs didn't get enough vitamin D. How can you tell?

Vitamin D is called the sunshine vitamin. Your skin uses sunlight to make vitamin D. But suppose your skin is covered by clothing. Or suppose you spend the day inside. Then you have to get vitamin D from your diet. Today vitamin D is added to milk and dairy foods.

You also get *vitamin A* from dairy foods. You need vitamin A for healthy skin. Your eyes need vitamin A to work well. You can eat green and yellow fruits and vegetables to get vitamin A. Vitamin A is found in liver and eggs too. How do you get the vitamin A you need in your diet?

Your Diet

Now you know more about nutrition than anyone who lived a hundred years ago. You can use what you know to make sure *your* diet has the nutrients you need. Here is one way.

You know different foods have different nutrients in them. Every day, try to eat foods from the first four food groups. Then you'll probably get the nutrients you need.

Things You Know

1. Why do you need vitamin A and vitamin D in your diet?
2. What foods are good sources of vitamin A? Vitamin D?
3. How can you be sure your diet has all the nutrients you need?

Finding Out in the Library: Vitamin K

To stay healthy, you need very small amounts of different vitamins. One of these is vitamin K. Vitamin K is found in foods such as cheese, egg yolk, liver, alfalfa sprouts, and spinach.

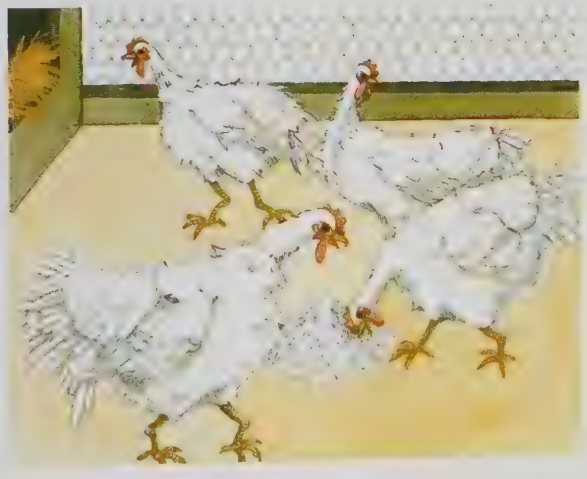
However, there is another way your body gets the vitamin K it needs. Find out what this way is. Also find out why your body must have vitamin K.

Using What You Know

A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. People who do not have enough vitamin C often develop (scurvy, beriberi).
2. The cause and cure for pellagra was found by (Dr. Goldberger, Dr. Eijkman).
3. To prevent pellagra, eat foods rich in (niacin, thiamine).
4. For a healthy skin, your body needs (thiamine, vitamin A).
5. Your skin uses sunlight to make (vitamin A, vitamin D).
6. Citrus fruits are rich in (niacin, vitamin C).
7. To have strong bones, your body needs (vitamin D, vitamin B).
8. To get enough vitamin A, eat plenty of (green and yellow vegetables, peas and beans).
9. Two foods rich in niacin are whole wheat bread and (carrots, meats).
10. A disease that make people too tired and weak to work is (beriberi, scurvy).

B. Look at the picture. Tell what disease was studied. Then tell what experiment was done and what was learned.



Science and Technology:

On a Modern Farm

You might not agree about which of these is the greatest technology. You might say the greatest technology is the one that produces gasoline. Or the one that produces electricity. Some would say it is the technology that gives us our food. You probably would not be alive if farmers didn't grow your food.

Farms of today are different from farms 200 years ago. Then, farmers used muscle and the technologies of the wheel and plow. Today, farmers use the technologies of the machine and the engine. A modern farm uses electricity to light barns and to milk cows. Gasoline and oil are used to run machines that can plow, seed, and harvest the fields.

A modern farmer may use automobiles, trucks, tractors, seeding machines, and harvesters. The modern farm is a model of the wise use of soil, plants, animals, and the human brain. After all, men and women invented farming. Technology makes the farm possible. What new technologies might a farmer use?

Another View:

Why do we need green plants?

Every day you eat. In a way, you eat to give your body the things it needs to grow strong and stay healthy. The foods you eat give you the nutrients you need. These nutrients are proteins, carbohydrates, fats, minerals, vitamins, and water.

You also need the right amount of each nutrient. For example, if you don't get enough calcium you won't have strong bones and teeth. Without enough vitamin C, you might get scurvy. A good diet gives you all the nutrients you need.

All the foods you eat can be traced back to green plants. You know fruits and vegetables are green plants. Bread and cereals are made from green plants. But what about many of the foods in the Meat Group? Chickens, for instance, eat foods that come from green plants. Cows do also. So foods in the Milk Group really come from green plants.

You Know A Great Deal

A. Choose the term that makes each sentence correct. Then write the letter of the term you choose in your science notebook.

1. To sprout, seeds must have
   a. water b. light c. chloroplasts
2. Plants take in water and minerals through their
   a. stems b. leaves c. roots
3. When you eat spinach or lettuce, you eat food stored in
   a. fruits b. roots c. leaves
4. The outside of a plant cell is the
   a. cell wall b. cell membrane c. nucleus
5. The green compound in plant leaves is
   a. niacin b. chlorophyll c. thiamine
6. Green plants use the Sun's energy to make food and
   a. nitrogen b. sodium chloride c. oxygen
7. Meat and beans are a good source of the nutrient
   a. carbohydrate b. fat c. protein
8. The mineral the body needs for good red blood cells is
   a. calcium b. iron c. sodium
9. Oranges and grapefruit are good sources of
   a. vitamin A b. vitamin C c. vitamin D
10. Dr. Eijkman found that eating brown rice and other whole grains can cure
    a. beriberi b. pellagra c. scurvy

B. Answer each question.

11. Name the five food groups. Then list three foods in each group.
12. Which food group is not needed for a good diet? Why?

A Project: Analyzing Your Diet

Would you say you have a good diet? Perhaps you'll make a chart like this one in your notebook. Then you can keep a record of the foods you eat during the next week. How many foods did you eat from each of the food groups every day?

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Breakfast	oatmeal, milk						
Lunch	tuna sandwich, apple juice, orange						
Dinner	hamburger, salad, milk						
Snacks	apple, cookies						

Books For You:

What to Eat and Why: The Science of Nutrition, by R.V. Foder, published by Morrow, New York, 1979. If you want to find out more about nutrition and foods, read this book.

The Breadbasket Cookbook, by Sue John, published by Philomel, 1982. Learn how to bake your own bread and use it as a basis for several kinds of unusual sandwiches.

The 100-Year-Old-Cactus, by Anita Holmes, published by Four Winds, New York, 1983. With beautiful pictures, this book tells about the saguaro cactus in the Arizona desert. This cactus is used for food, moisture, and shade by desert animals.

Living Longer

Both pictures show children in a school playground. There is a great difference, however. The children in the first picture were likely to get certain diseases. The children in the other picture are not likely to get these diseases. You'll soon see why.

About a hundred years ago, many people died of *cholera*. It was a feared disease. Today, where water is purified, we rarely hear of cholera.

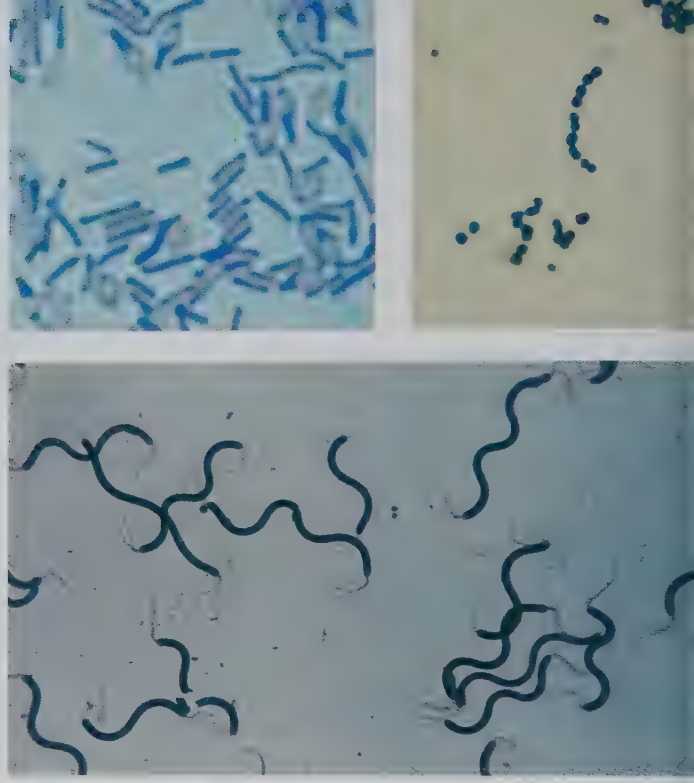
Unit 6

It was only a little over a hundred years ago that scientists learned about germs. It took time to learn that germs cause disease. It took time to learn where germs live outside the body. It took time to learn that cholera germs live in water.

Today, health workers test the water you drink for germs. Doctors and health workers have protected us against many diseases. A hundred or so years ago, water was not tested for germs. Today, the technology of testing water and food saves lives. Possibly it has saved yours.

19

Tiny Living Things Around You



No doubt you have heard about germs. You already know about one kind of germ–bacteria. You know bacteria are so small we need a microscope to see them. With a microscope we can see three kinds of bacteria. Look at the three different shapes. Describe each shape.

A
Too Small to See

Lazzaro Spallanzani was an Italian scientist. He lived about 200 years ago. He grew tiny living things in a soup made from seeds. Then Spallanzani observed the living things through a microscope. We now know he was probably looking at bacteria.

Spallanzani wondered what he would see if he could get one of these living things by itself. He placed

a drop of soup on a piece of glass. Patiently he watched the bacteria move. Finally, he got one bacterium by itself.

He watched and waited. He saw an amazing thing! The bacterium divided into two. That's how bacteria make more bacteria like themselves. They divide.

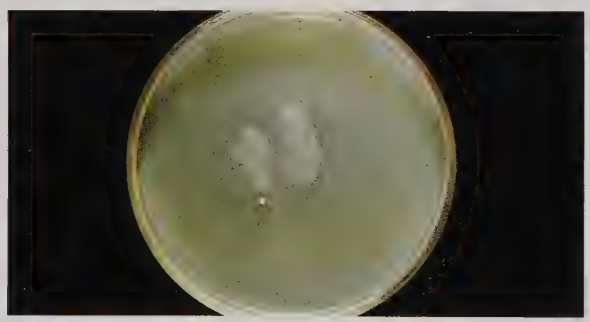
Robert Koch, a German doctor, was a scientist who worked about 120 years ago. He wanted to find a way to make bacteria he grew stick together after they divided. That way the bacteria might be seen without a microscope.

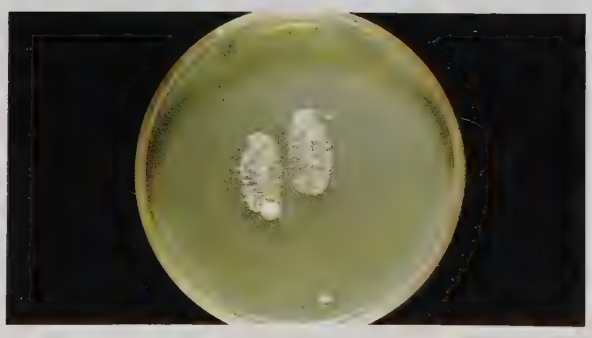
An assistant in Koch's laboratory thought that bacteria might grow well on food-gel. Because the gel was sticky, she thought the bacteria would not move. They would stick together. When bacteria stick together, they form a **colony.** Colonies of bacteria could grow on the food-gel.

Here are two dishes of food-gel on which bacteria are growing. Look at the colonies. Millions and millions of bacteria are found in each colony. Why not grow some bacteria yourself?

Finding Out:

How can we grow bacteria?





You will need three special dishes with covers. Inside each dish is food-gel. The food-gel has water, carbohydrates, and proteins in it.

Open one dish. Touch the food-gel with your fingers. Then cover the dish. Fasten the cover on the dish with tape.

Open another dish. Put some chalk dust in it. Fasten the cover on the dish with tape.

Leave the third dish open to the air for a few hours. Then fasten a cover on this dish. *Do not open the dishes at any time.*

Put the dishes in a warm, dark place overnight. Do you see tiny spots on the food-gel the next day? These spots are colonies of bacteria.

Wait another day. Then look at the dishes again. Are the colonies larger? Why?

Never open a dish in which bacteria are growing.

1. Suppose you observe bacteria with a microscope. Draw and describe three different shapes of bacteria you might see.
2. How do bacteria make more bacteria like themselves?
3. How can you grow colonies of different shapes of bacteria?

Careers: In Health

Doctors, nurses, and dentists are not the only people who help keep us healthy. Many other people work to help us live longer and healthier lives. Perhaps you'd like to be one of them.

Researcher

Laboratory technicia

Therapist

Supply clerk

Druggist

Defense Against Bacteria

It seems bacteria are all around us. Then why aren't we sick all the time? First, not all bacteria are harmful. Indeed, not all bacteria cause disease. Some bacteria help make soil rich. And you know plants grow better in rich soil.

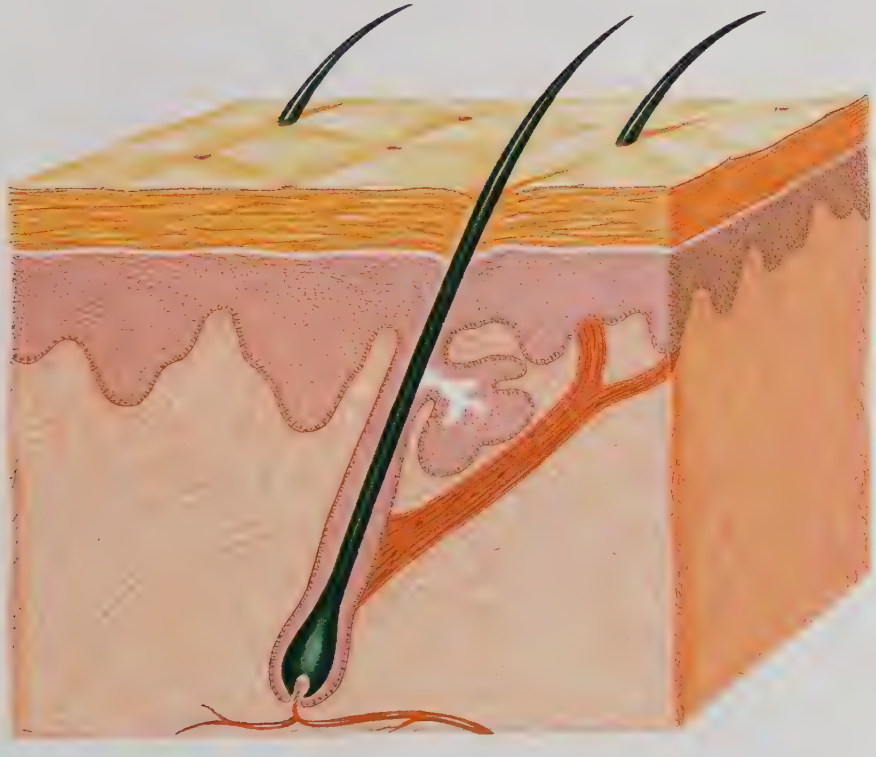
We use bacteria for making buttermilk and some kinds of cheeses. We use bacteria to make yogurt too.

Second, your body is well prepared to deal with bacteria. As you shall see, your body has ways of keeping out bacteria. And ways of getting rid of bacteria that might get in.

Keeping Bacteria Out

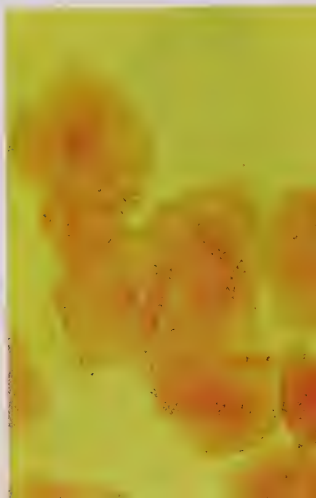
Your body is covered with skin. Your skin protects your body on the outside. Skin helps keep bacteria and other germs out of your body. As long as your skin isn't cut or broken, bacteria can't get through it.

Your skin is made up of two layers. Each layer is made up of cells. Cells cover the outside of your body. Cells also cover the inside of your body. The cells inside your cheeks are one kind of covering cell.



Of course, cells can't be seen without a microscope. These cells have been magnified many, many times. Perhaps you know your body is made up of many kinds of cells. If you become sick, your cells can't work properly.

Your skin is your first defense against bacteria. Soon you will learn how to protect your skin. But often bacteria get into your body in another way.

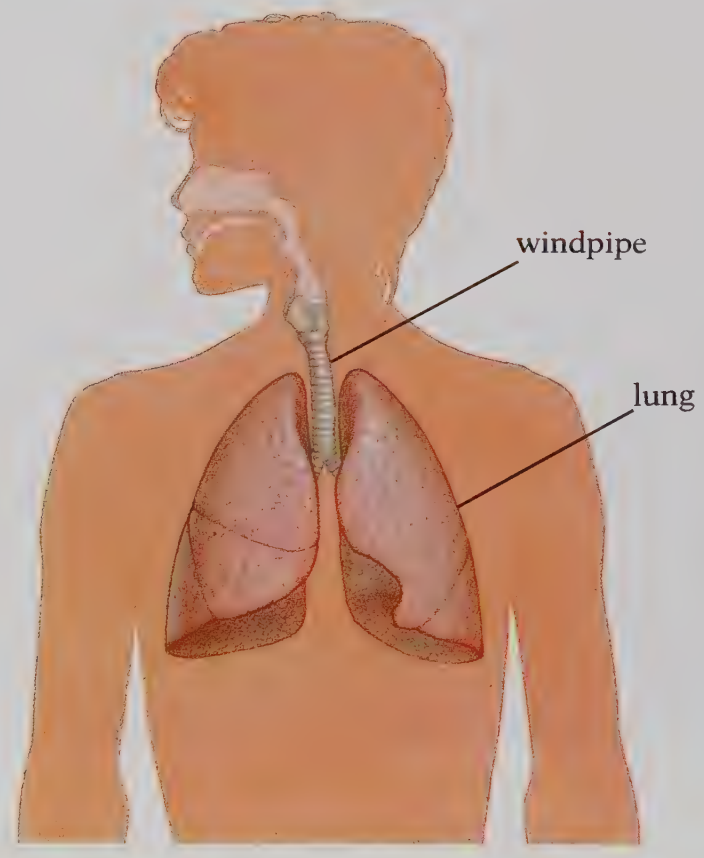


Getting Rid of Germs

mucus (mü'kəs)

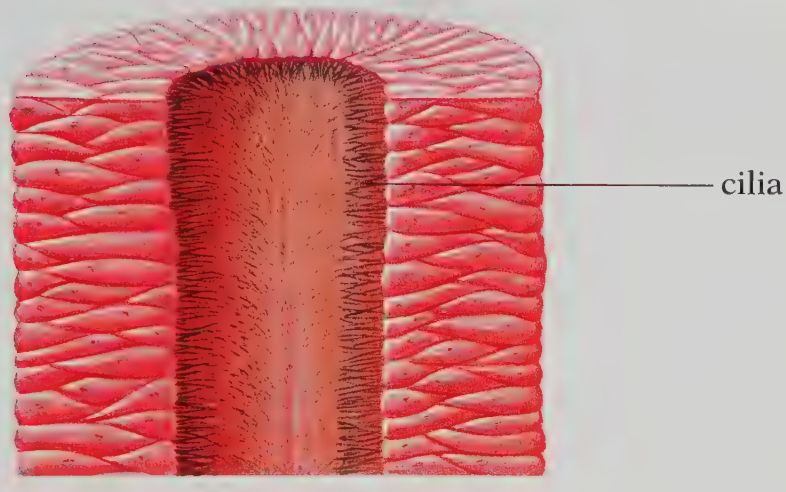
Bacteria and other germs may be in the air around you. They may get into your body when you breathe. But your body can usually get rid of these bacteria.

Special cells line the inside of your mouth and nose. These cells make a sticky substance called *mucus.* Sticky mucus traps bacteria. Whenever you blow your nose or sneeze, you blow out mucus and trapped bacteria. One sneeze may send out millions of bacteria. Now you know why you should use a handkerchief to cover a sneeze.



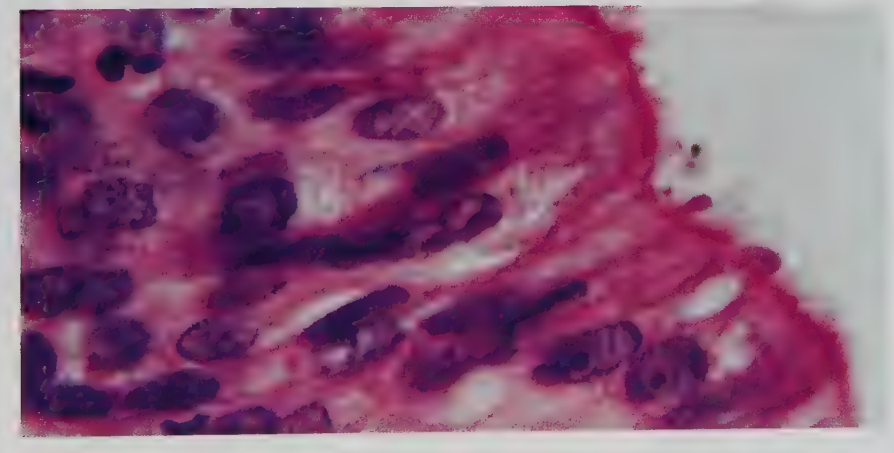
Suppose bacteria aren't trapped by mucus in your nose and mouth. Then the bacteria may get into your *windpipe.* When you breathe, air goes through your windpipe to your lungs.

Your windpipe is also lined with cells. Some of the cells make mucus. Many of the cells have tiny hairs.



These hairs are called *cilia*. Look at the cells with cilia in this picture. It was taken with a microscope. What do you think cilia do?

cilia (sil'ē·ə)



Cilia sweep trapped bacteria up your windpipe. Then when you cough, you send out some bacteria. Why should you cover your mouth when you cough?

Skin, mucus, and cilia help protect your body. Yet bacteria may still get in.

Bacteria with Food

When you cook food, you kill most of the harmful bacteria in it. But some bacteria may not be killed.

You probably know your stomach *digests* the food you eat. To digest food means to break it down. Your stomach makes a substance called an *acid.* This acid helps digest food. This acid also kills bacteria that may be swallowed with your food.

Things You Know

1. Name some ways that bacteria help us.
2. How does your skin help keep bacteria out of your body?
3. Describe three ways the body protects itself against bacteria that get into it.

Finding Out in the Library: Leeuwenhoek's Microscopes

Do you have a hobby? Perhaps you collect stamps or make models of cars.

Anton van Leeuwenhoek was a Dutch shopkeeper who lived more than 100 years ago. Anton van Leeuwenhoek had a hobby. He liked to make microscopes. In fact, he made more than 250 microscopes.

With his microscopes, he studied many kinds of things. He saw tiny living things in a drop of water. Today we know Leeuwenhoek saw bacteria with his microscopes.

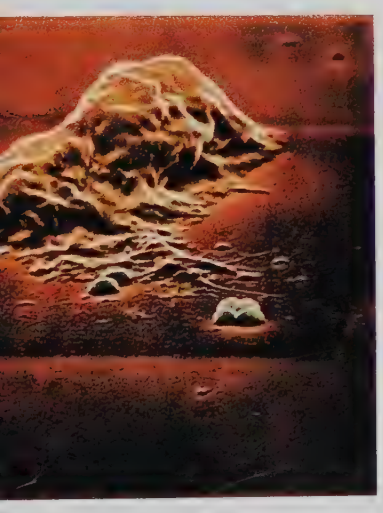
Find out what Leeuwenhoek's microscopes looked like. How are they different from microscopes we use today?

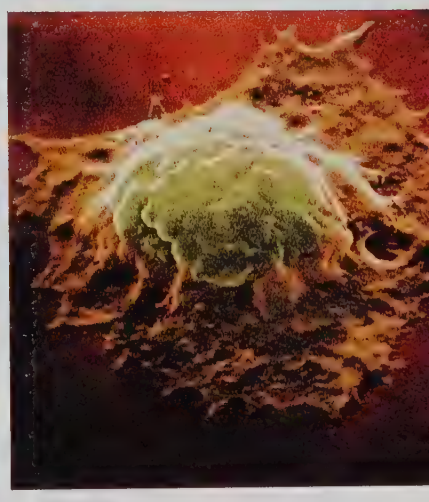
Fighting Germs

Surely you have cut yourself. Perhaps the cut became swollen and red. Bacteria can enter your body through an open cut. Then your body does something to protect itself.

Some cells in your blood can move by themselves. These cells are your *white blood cells.* Let's look at white blood cells through a microscope. Let's watch what happens when bacteria get into your blood.

First, the white blood cells hurry toward the cut in the skin. Then the white blood cells surround the bacteria and digest them.





Perhaps you've had a cut that had *pus* in it. Pus shows that your white blood cells are destroying bacteria. When white blood cells fill with bacteria, the white blood cells die. Pus is made mainly of dead white blood cells.

Don't wait for bacteria to get into your body through a cut. You can prevent bacteria from getting in. Let's see how.

Finding Out:

Can the growth of bacteria be stopped?

You will need five dishes with food-gel in them. Open each dish and touch the food-gel with your fingertips.

Add some iodine to one dish. Be sure the iodine flows over all the food-gel.

Flood the second dish with Merthiolate. Flood the third dish with chlorine bleach. Do not add anything to the last two dishes.

Cover all the dishes. Fasten the covers with tape. Label the dishes. Put the dishes in a warm, dark place. **Remember: Do not open the dishes at any time.**

Look at the dishes the next day. Are bacteria growing in any of the dishes?

Observe the dishes for a few days. In which dishes do bacteria grow?

Do any of the substances you added prevent bacteria from growing?

Helping Your Body Fight Bacteria

Substances like iodine and Merthiolate are called **antiseptics.** You saw that an antiseptic will help stop bacteria from growing.

When you get a cut or bruise, have an adult help you wash it with soap and warm water. Then ask the adult to put some antiseptic on it. The adult may want to cover the cut with a bandage. That will help keep the cut clean. If the cut becomes swollen, you should see a doctor. A doctor will know what else to do.

antiseptic
(ant·ə·sep'tik)

Today doctors use antiseptics before they operate. But this was not always so. Imagine an operating room more than 120 years ago. No one knew that bacteria and other germs could cause disease. Antiseptics weren't used. Many people died from germs that came from the doctor's hands and instruments.

Later it was learned that some bacteria cause disease. Antiseptics could help keep bacteria from getting into the body. Joseph Lister, an English doctor, was the first to use antiseptics in the operating room.

Help from a Mold

Perhaps you have seen *molds* growing on bread, on oranges, or on other fruits. Molds are plants. But molds do not have chlorophyll in them. So molds cannot make their own food. Molds must get their food from other plants or animals.

Some scientists were studying bacteria in their laboratory. They were growing colonies of bacteria in dishes of food-gel. They were also growing some molds they wanted to study.

Alexander Fleming was one of these scientists. One day he noticed something strange. Some greenish-blue mold had gotten into a dish where bacteria were growing. And around that mold, the bacteria did not grow.

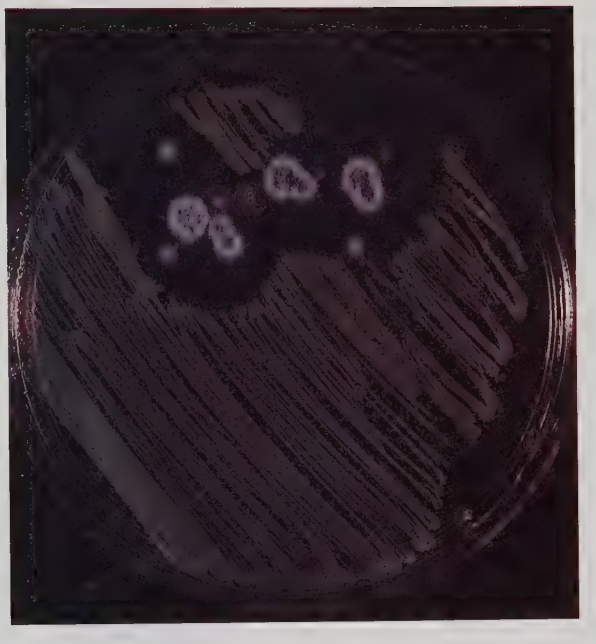
An Explanation

Alexander Fleming knew:

Bacteria were growing in his dishes.
Some mold had gotten into one dish.

He observed:

Bacteria kept growing in the other dishes.
But bacteria stopped growing near the mold.



Perhaps Fleming thought:

If bacteria don't grow around the mold,
then the mold may be destroying bacteria.

We say Fleming formed a **hypothesis.** A hypothesis is a possible explanation of things that happen. Of course, scientists need to test their hypotheses. And they do.

hypothesis
(hī·päth'ə·səs)

Scientists do more experiments. Then they can make more observations. Even then scientists depend on other scientists to repeat their work. Only when a scientist's work is repeated many times, are the findings thought to be correct.

Alexander Fleming and other scientists did many experiments. They grew colonies of bacteria in many dishes. They added mold to some of these dishes. To the rest of the dishes, they did not add mold.

In the dishes *without* mold, bacteria kept growing. In the dishes *with* mold, bacteria did not grow. Over and over again, the results were the same.

Fleming found that a certain substance in the mold destroyed bacteria. The mold was *Penicillium* so he named the substance penicillin. Perhaps you have had penicillin sometime when you were sick.

antibiotic (ant·i·bī·at'ik)

Penicillin was the first **antibiotic** discovered. An antibiotic is a substance that is made by a living thing and that destroys bacteria. Aureomycin and streptomycin are two other antibiotics. What antibiotics have you had?

Things You Know

1. Describe what the body does when bacteria get into a cut.
2. How is an antiseptic different from an antibiotic?
3. What is a hypothesis? How did Fleming and other scientists test his hypothesis?

Using What You Know

Write the answers to all questions in your science notebook.

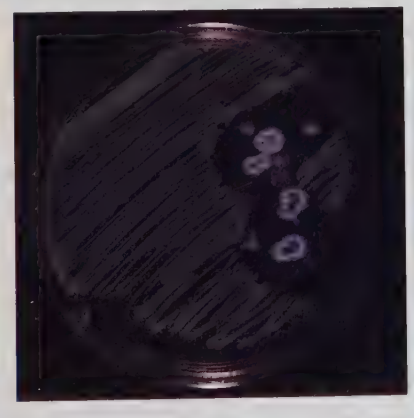
A. Read each sentence. Use words from the list below to fill in the blank spaces.

antibiotic, antiseptic, cilia, food-gel, hypothesis, microscope, skin, white blood cells

1. To see bacteria, you must use a (an) _____.
2. A substance that helps stop bacteria from growing is a (an) _____.
3. The body's first defense against bacteria is the _____.
4. Your windpipe is lined with mucus and tiny _____.
5. If bacteria get into a cut, they are soon surrounded by _____.
6. A substance that is made by a living thing and destroys bacteria is a (an) _____.
7. A possible explanation of things that happen is a (an) _____.

B. Describe what you see in each picture.

8.



9.

10.

20

Another Kind of Defense

Perhaps, you have had the *measles.* Perhaps some of your friends have. Once you've had measles, why don't you usually get them again?

It took the work of many scientists to answer this question. They learned that your body has another kind of defense against some diseases.

A

When a Virus Gets Inside

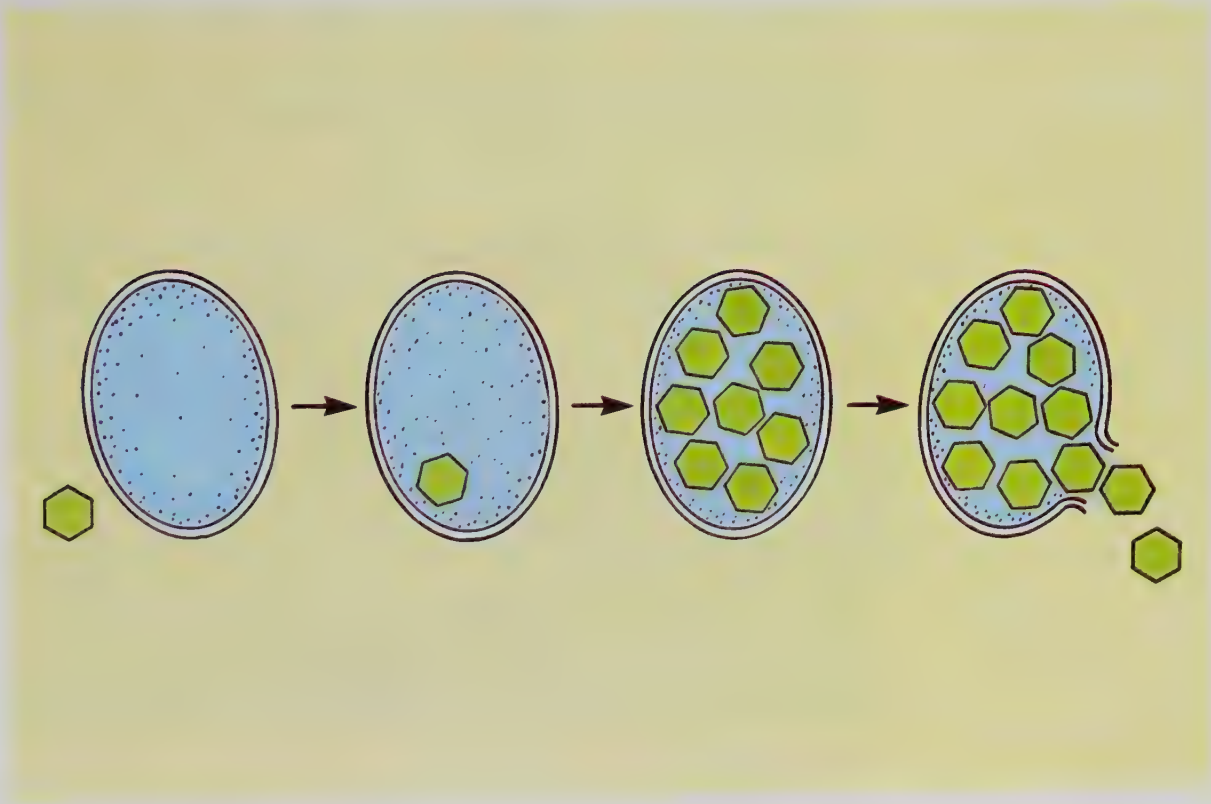
virus (vī'rəs)

Measles is caused by a tiny kind of germ, a **virus.** A virus is very small. It is very tiny indeed.

Imagine a cheek cell as large as your classroom. Imagine the cell fills the whole room. Then your chair would be about as big as the nucleus of the cheek cell. But the nucleus would be round and puffy, like a basketball.

Now think of one small paper clip on the floor of the room. That's about the size of a virus when it gets into a cell.

Scientists are not sure how a virus causes disease. But they do know that a virus uses a cell for food. Once a virus gets into a cell, the virus makes more viruses like itself. Soon the new viruses fill the cell. Then the cell breaks open. The new viruses leave the cell. The new viruses can now go into other cells.



This happens over and over again very quickly. In a short time, many of the cells of the body are filled with viruses.

You may become very sick when your cells fill with viruses. But as soon as a virus gets into your body, your body begins to fight back.

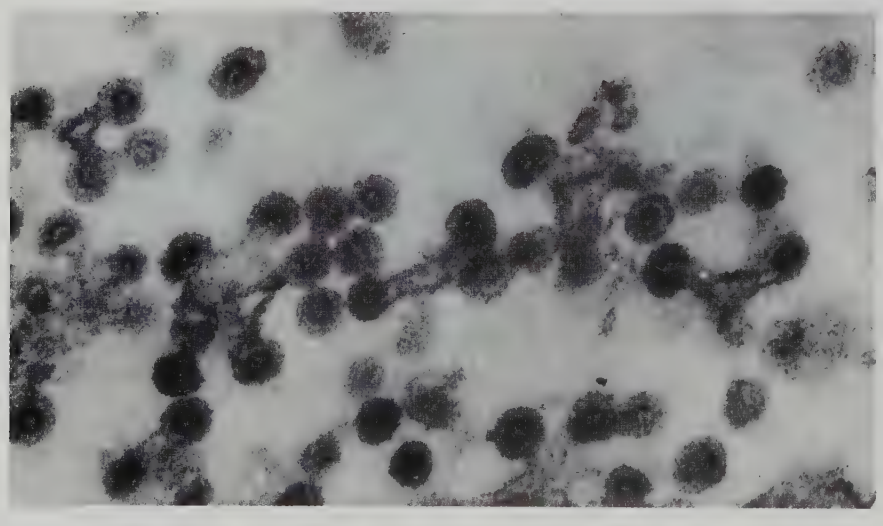
Your Body Fights Back

antibody
(ant·i·bäd′ ē)

You know your body has many defenses against disease. The skin is one defense. So are white blood cells. The acid in your stomach is a third. **Antibodies** are yet another way your body defends itself.

Antibodies act against viruses and other germs that get into your body. When you get measles, your body makes antibodies against measles. These antibodies stay in your blood. Once you get well, you will probably never have measles again. We then say you are **immune** to measles.

When you are immune to measles, your body has antibodies that act against the virus that causes measles. These antibodies will act against the virus if it gets into your body again.



Measles virus

Your body makes different antibodies against different diseases. So to be immune to a disease means you are safe from that disease. Not from other diseases – just that one.

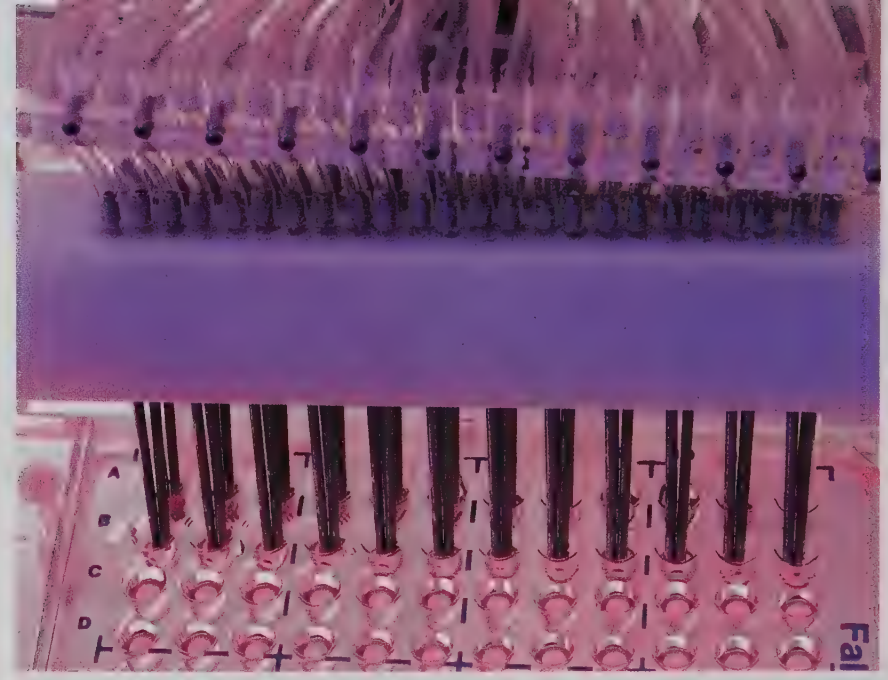
But you don't have to get a disease to become immune to it. You may become immune another way.

Before you started school, you probably had shots, or *vaccinations,* against certain diseases. You probably had vaccinations against *polio, diphtheria, tetanus, whooping cough,* and *measles.* Vaccinations can make you immune to these diseases. Why is it so important to be immune to them?

A vaccination record tells which vaccinations you have had. Make a record like this one in your notebook. *Do not write in this book.* Find out which diseases you are immune to.

You probably had more than one vaccination against certain diseases. Your school health record or your doctor can tell you which vaccinations you have had. Compare your vaccination record with your friends.

Disease	Vaccination	Date given
Polio	First	
	Second	
	Third	
	Fourth	
Diphtheria, Tetanus, Whooping Cough	First	
	Second	
	Third	
	Fourth	
	Fifth	
Measles	One Only	



Vaccines are substances made from bacteria or viruses. The germs used to make some vaccines have been made weak enough not to harm you. Heating, for example, is one way to weaken germs. Sometimes the germs used to make vaccines are dead. When you are vaccinated, your body makes antibodies against the dead or weakened germs.

You have probably been vaccinated against diphtheria. Now suppose diphtheria germs from the air enter your body. Your body begins to make antibodies against the germs. But you don't get the disease. Vaccinations help you become immune to a disease without having it.

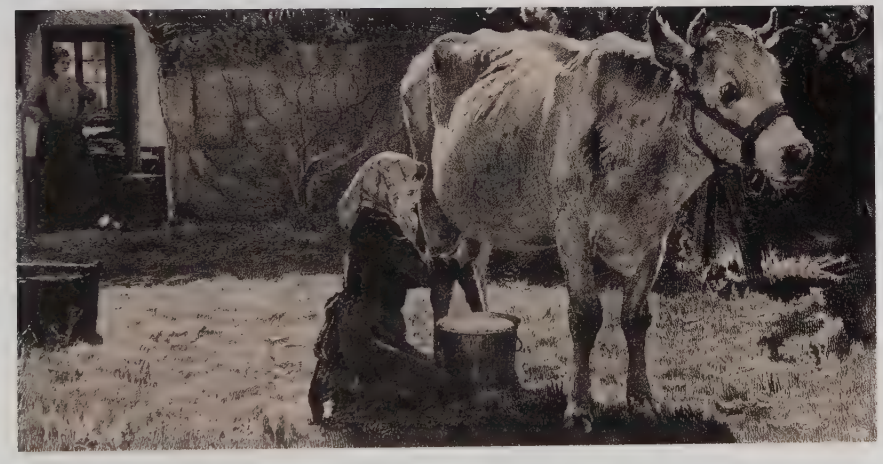
Things You Know

1. What happens to a virus that gets into a cell of your body?
2. Once you have measles, you will probably never have them again. Why?
3. What takes place in your body when you are vaccinated against polio?

Scientists Against Disease

How was the idea of vaccination discovered? The story begins in England almost 200 years ago. Many people got a disease called *smallpox.* Many people died from this disease. People didn't know smallpox is caused by a virus. In fact, people didn't know much about germs then.

At that time, many cows got a disease called cowpox. People who milked these cows sometimes got cowpox. But these people didn't get smallpox. How strange!



Edward Jenner was an English doctor. He had been treating people for cowpox and smallpox for many years. He observed: Cowpox is very much like smallpox. People who get cowpox don't get smallpox. He wondered: Does cowpox make people immune to smallpox?

Dr. Jenner formed a hypothesis:

If I could give a person cowpox,

then the person would not get smallpox.

Now he had to test his hypothesis.

It happened that the parents of a young boy wanted to be sure he didn't get smallpox. They knew cowpox would not harm their son. So they gave Jenner a chance to test his hypothesis.

Jenner gave the young boy cowpox. He waited until the boy was well again. Then he tried to give the boy smallpox. But the boy didn't get sick. His body had made antibodies that protected him from smallpox. The boy was immune to the disease.

Edward Jenner had taken a big step in the fight against diseases. He had found a way to make people immune to smallpox. He vaccinated them with cowpox. Now people could live without fear of smallpox.

By the way, the Latin word for cow is *vacca.* Now you see where the word vaccination comes from.

Louis Pasteur

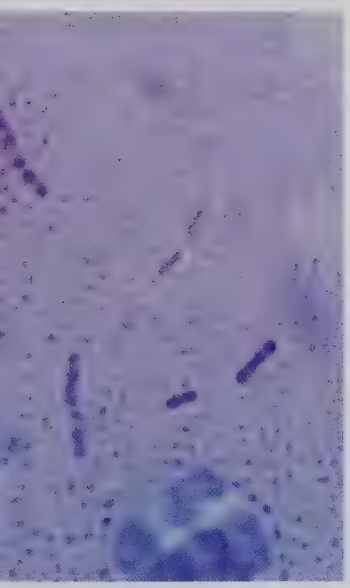
About 120 years ago in France, Louis Pasteur was studying bacteria. He showed that bacteria lived almost everywhere. He found that air carried bacteria that could spoil wine. And he found that heat killed such bacteria.

Today the use of heat to kill many germs is called *pasteurization.* The milk you drink has probably been pasteurized.

pasteurization (pas·chur·ə·zā′shən)

When food is pasteurized, it is first heated. Then the food is cooled quickly. Pasteurization keeps germs in food from multiplying rapidly. But pasteurization does not change the flavor of food.

Pasteur wondered: If germs could spoil wine, what else could germs do?



Many sheep in France were dying. They had a disease called *anthrax.* Pasteur studied blood from these sheep. With a microscope, Pasteur saw germs in the blood of sheep that died. Again and again, he found the same kind of germ. The germs were bacteria that looked like these. What shape do the bacteria have?

Pasteur found he could weaken the bacteria that caused anthrax. He vaccinated some healthy sheep with the weakened germs. The sheep got anthrax, but didn't die. The sheep had made antibodies against the weakened anthrax bacteria. Pasteur's vaccine had made the sheep immune to the disease.

Perhaps you have heard of a disease called *rabies.* Rabies is caused by a virus that attacks part of the brain. Louis Pasteur made the first vaccine against rabies. He studied how weakened rabies germs could make people immune.

A little boy, Joseph Meister, was bitten by a dog that had rabies. The boy would have died from rabies. But he got some of Pasteur's first rabies vaccine. Thanks to Pasteur, the boy's life was saved.

Robert Koch

Robert Koch, like Pasteur, thought that germs caused disease. Koch grew anthrax bacteria in dishes of food-gel. He showed that only anthrax bacteria could cause anthrax. He showed that one kind of bacterium caused one kind of disease.

Koch tried to find the cause of *tuberculosis.* He found bacteria like these in people and animals that had the disease. He thought these bacteria caused tuberculosis. But he had to be sure.

tuberculosis
(tü·bər·kyə·lo'sis)

So first he grew colonies of these bacteria in dishes. Then he gave the bacteria to some healthy animals. The healthy animals got sick. They got tuberculosis. He did not give any bacteria to other healthy animals. These animals did not get the disease.

Koch studied the bacteria that grew in the sick animals. He compared these bacteria with the bacteria he started with. The bacteria were the same kind. Now he was sure these bacteria caused tuberculosis.

The work of Louis Pasteur and Robert Koch gave the world a new way of looking at disease: Germs, such as some kinds of bacteria, cause disease. Scientists later found that not all diseases are caused by bacteria.

Jonas Salk and Albert Sabin

You know viruses are very small. In fact, they are much, much smaller than bacteria. In the picture at the left, the viruses are the dark dots. Some of the viruses are inside the bacterium.

You also know viruses can cause diseases. Measles is caused by a virus. Smallpox is caused by another virus. The virus in the picture at the right causes polio.

The polio virus attacks nerve cells. Nerve cells send messages from the brain to the muscles. Without these messages, muscles cannot move.

Some children with polio could not use their leg muscles. They could not walk. Some children could not move their arms. Sometimes their chest muscles wouldn't work properly. So it was hard for some children with polio to breathe.

Until about 30 years ago, many children got polio. Now we have vaccines against this disease.

Jonas Salk found that dead polio viruses could make people immune to polio. Perhaps you have been vaccinated with Salk vaccine.

Salk vaccine

Sabin vaccine

Albert Sabin had a different idea. He didn't kill the polio viruses. He weakened them to make a vaccine. He found the weakened viruses also made people immune to polio. And he found the vaccine could be given by mouth. Perhaps you have had the Sabin vaccine to make you immune to polio.

Things You Know

1. Jenner and Pasteur discovered important things about disease. Describe one thing each scientist discovered.
2. How did Koch show that tuberculosis was caused by a certain kind of germ?
3. Describe two different kinds of vaccines against polio.

Chapter 20

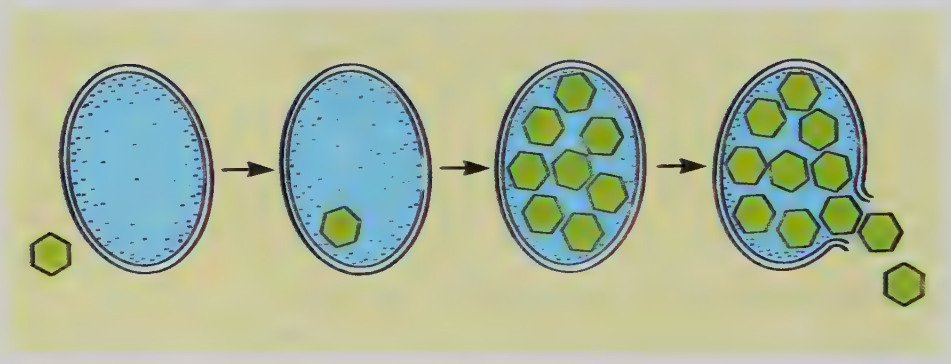
Using What You Know

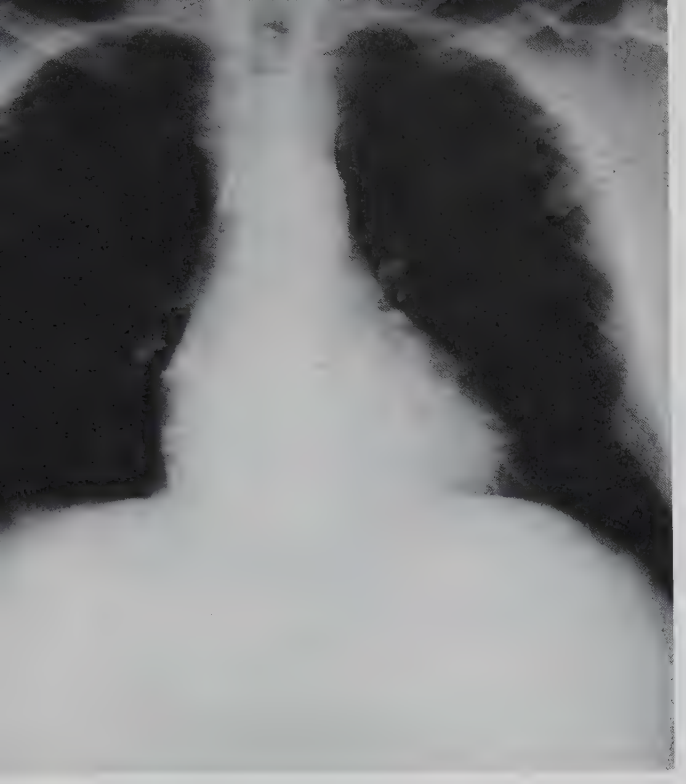
A. Read the sentences below. One of the underlined terms makes the sentence correct. Write the correct term in your science notebook.

1. The germ that causes measles is a (virus, bacterium).
2. Jenner vaccinated a boy with cowpox to make him immune to (rabies, smallpox).
3. If you have diphtheria, your body makes (antibiotics, antibodies).
4. If you are vaccinated against diphtheria, you are (immune to, sick with) diphtheria.
5. Dr. Salk and Dr. Sabin produced vaccines against (anthrax, polio).
6. The scientist who showed that certain bacteria caused tuberculosis was (Pasteur, Koch).
7. Weakened germs are used to produce (vaccines, pasteurization).
8. Viruses are much (smaller, larger) than bacteria.
9. A virus that attacks the nerve cells that lead to muscles causes (tetanus, polio).

B. Answer each question.

10. How does measles vaccine make you immune to measles?
11. What is happening in the picture?





21

Toward Living Longer

The work of scientists and doctors has given us much information about the body. As you study science you will learn more about how your body works.

Let's take a look inside the body. This *X-ray* picture shows the upper part of the body. Find the lungs and the heart. What do they do?

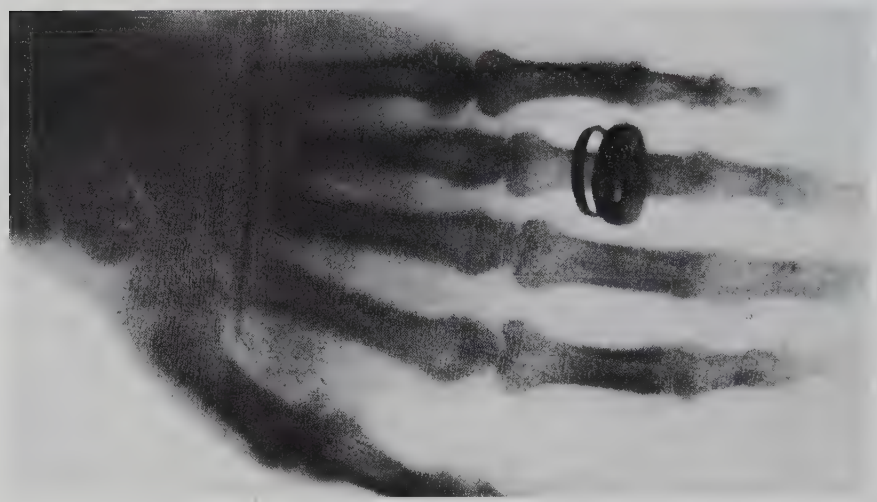
A
Inside You

Could the picture be an X-ray picture of George Washington's lungs? What do you think?

Almost 100 years ago an X-ray picture was not possible. While Wilhelm Roentgen, a German scientist, was studying electricity he noticed some strange rays. Roentgen then discovered what these rays could do.

X Rays

Roentgen found that the rays went through paper, wood, and aluminum. They went through skin and other soft parts of the body. With these rays, he saw the bones inside his wife's hand. And he saw the ring on her finger. Roentgen called the strange rays *X rays*.



Here a doctor examines an X-ray photograph. It shows a broken arm. The doctor takes an X ray to see inside the arm. Then he can fix the broken bone. You may have had an X ray. If so, what happened?

Explain why an X-ray machine is a technology.

Listening Inside

The child in the picture lies still. But inside, her heart beats. Blood flows. Air goes in and out of her lungs.

Heart, blood, air—each makes its own sounds. A doctor can hear these sounds.

Perhaps a doctor has used a *stethoscope* to examine you. A doctor uses a stethoscope to hear different sounds inside you.

stethoscope
(steth'ə·skōp)

Things You Know

1. Name several things X rays go through.
2. Why does a doctor take an X-ray picture if she thinks you have a broken foot?
3. Why may a doctor use a stethoscope to examine you?

Being Normal

Your heart beats. As it beats, blood flows all through your body. You can feel this flow of blood. Put your hand over your heart. You can feel your heart beating.

Place two fingers on your wrist, as you see in the picture. As your heart beats, you feel the flow of blood, or *pulse*. Be sure you can feel your pulse.

The number of times your heart beats in one minute is called your *pulse rate*. Your pulse rate tells important things about your body. For example, when you run fast, your pulse rate speeds up. That means your heart is pumping blood more quickly.

You may have heard someone say, "She has a normal pulse rate." But everyone does not have the same pulse rate. What does *normal* mean?

Perhaps your teacher can help you find your pulse rate. Count the number of times your heart beats in one minute. Your teacher can tell you when to start and when to stop. Do this three times while you are sitting quietly in a chair.

Leslie is a student in the third grade. Here are the pulse rates she counted:

74 beats in one minute
76 beats in one minute
72 beats in one minute

Notice that she had three different pulse rates. Compare your results with hers.

Leslie wanted to know her usual pulse rate while sitting quietly. We say she wanted to find her *average* pulse rate. Leslie knew how to find an average.

First, she added the three pulse rates she counted. Then she divided by the number of times she took her pulse rate. She found her average pulse rate while sitting quietly was 74 beats in one minute.

$$\begin{array}{r} 74 \\ 76 \\ +\ 72 \\ \hline 222 \end{array}$$

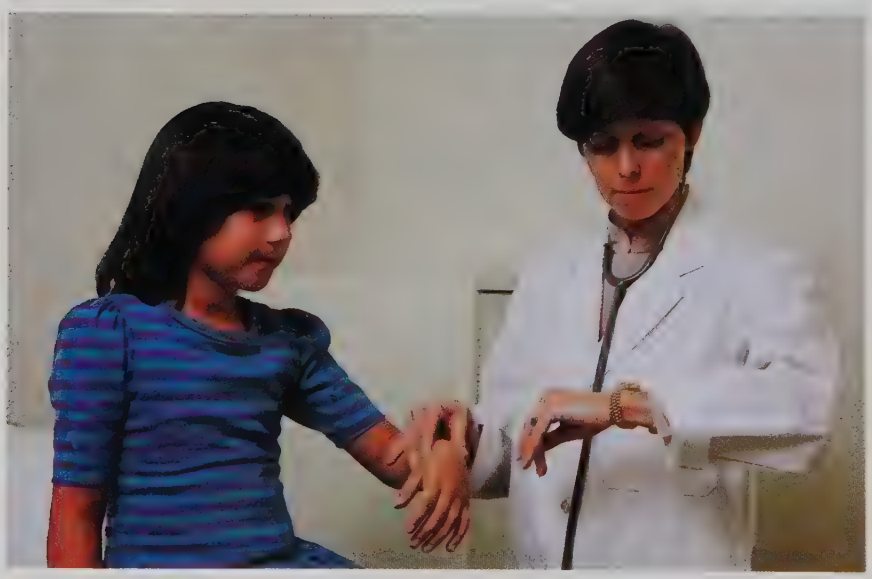
$$\begin{array}{r} 74 \\ 3\overline{)222} \\ -21 \\ \hline 12 \\ -12 \\ \hline 0 \end{array}$$

Paul is another student in the same grade. Paul's pulse rates were:

72 beats in one minute
68 beats in one minute
70 beats in one minute

Find Paul's average pulse rate. Isn't Paul's average pulse rate 70 beats in one minute? Compare your average pulse rate with Leslie's and Paul's.

Leslie had been to the doctor two days before she took her pulse rate in class. The doctor found her pulse rate was 74. The doctor told her sometimes her pulse rate would be higher or lower. But it was right for her to have a pulse rate around 74. Her pulse rate was *normal* for her.



It is normal for Paul to have a pulse rate of 70. Yes, his pulse rate is lower than Leslie's. But the rate is still normal for him.

Doctors have found that most people have a pulse rate of about 72 beats in one minute. What is your normal pulse rate?

Not everyone has the same pulse rate. What is normal for one person may not be normal for another person.

Each of these girls is 10 years old. Each girl is in good health. As you see, the girls are not the same height. Yet each girl's height is normal for her. Of course, your height is normal for you.

Things You Know

1. Does your pulse rate stay the same all day? How can you find out?
2. Describe how you can find your average pulse rate.
3. Is the same pulse rate normal for all the pupils in your class? Why?

35 Years Longer

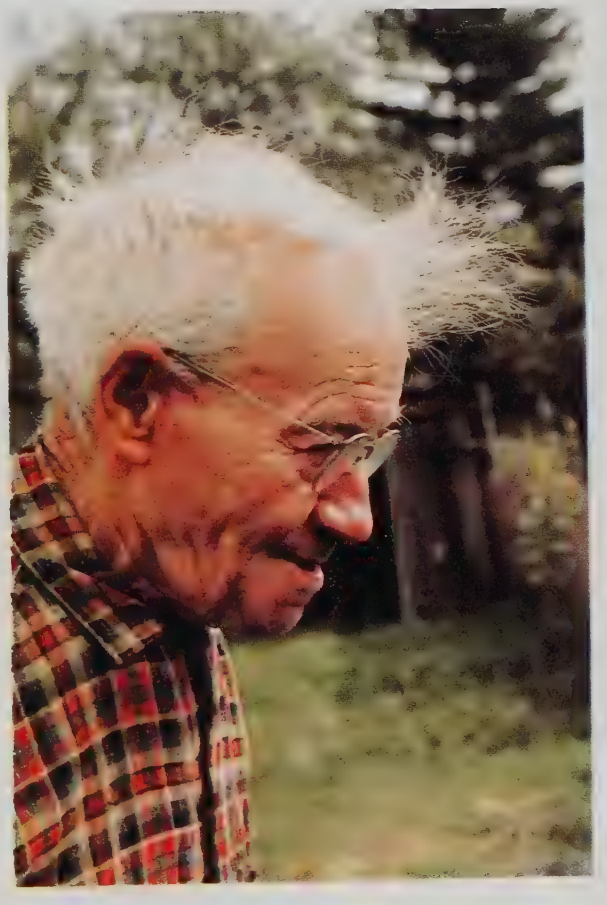
Americans live longer now than they did 120 years ago. Today we know more about keeping people healthy. We know a great deal more about good diets and nutrition. Recall the discoveries of vitamins and other nutrients. Name some diseases prevented by vitamins.

Recall the discovery of antiseptics and antibiotics—two kinds of germ killers. And recall the discovery of immunity. Once scientists learned that antibodies acted against certain germs, vaccines were made against some diseases.

Recall the work of many people who make sure your water is purified. They make sure the water you drink is free of bacteria that cause disease.

We say that people live longer. Perhaps it is better to say the average length of life is longer. What does this mean?

Imagine you were born 120 years ago. You might have lived to be more than 90 years old. Perhaps you would have lived to be 70 or 80. Or perhaps you would have lived to be only 5 or 10 years old. Most likely, you would have lived to be somewhere in the middle–around 40 years old. That was the average length of life 120 years ago.



Today the average length of life is about 75 years. Some people will live longer. But some people will die when they are young.

A child born today may expect to live to be 75 years old. How wonderful!

The work of many people has made it possible for you to live longer. Even so, a great part of taking care of your health and life is your task.

Some scientists think it is possible that in your lifetime, the average length of life may be over 100 years. But there is much work yet to be done.

Things You Know

1. How has the average length of life changed from 120 years ago until today?
2. Why is the average length of life today so much longer than it was 120 years ago?
3. What do you mean if you say the average length of life will soon be 80 years?

Finding Out in the Library: Life Span

The length of life is called the *life span.* Find the average life span in some other countries. Are there countries where the average life span is longer than yours? Where? Why might people in these countries live longer?

Using What You Know

Write the answers to all questions in your science notebook.

A. Read each sentence. Use terms from the list below to fill in the blank spaces. Do not use a term more than once.

average, bone, normal, skin, stethoscope, 35, 72, 75, 100

1. X rays do not pass through _____.
2. A doctor listens to your lungs with a (an) _____.
3. Most people have an average pulse rate around _____ beats in one minute.
4. If your average pulse rate is 68, then 68 is _____ for you.
5. You could weigh yourself every day for a week to find your _____ weight.
6. The average length of life today is _____ years.
7. The average length of life today is _____ years longer than it was 120 years ago.

B. Answer each question.

8. Why is the average length of life today longer than it was 120 years ago? Give as many reasons as you can.
9. Look at the picture of a person's chest. Which is the heart? Which is the lung?

Science and Technology:

Toward a Longer Life

Before you started school, you were probably vaccinated against diseases such as diphtheria and measles. You were made immune. That is, you would not get these diseases. What is behind this technology?

The experiments done by Louis Pasteur of France and Robert Koch of Germany are only part of the story. About 120 years ago, they showed that bacteria cause some diseases. Soon vaccines were made that protected people against some of these diseases. Now vaccines against many diseases are made in huge laboratories.

The technology that produces vaccines uses many inventions. Today, people and machines can produce millions of bottles of different vaccines.

Technology has also changed the way some vaccines are given. Many more people are receiving vaccines. Vaccines and other technologies have helped add about 35 years to the average length of life. In the years to come the average length of life may become longer. Do you know any recent discoveries to improve your health?

Surely when you get a cut an adult may help you clean it with soap and warm water. Then an adult may put some antiseptic on the cut and cover it with a bandage.

Suppose somehow bacteria get into your body. Then white blood cells rush to the bacteria. In a way, white blood cells "eat" bacteria. What if the white blood cells need help to kill the germs? We have antibiotics, such as penicillin, that destroy germs inside your body.

The body has other ways of fighting germs. The body may build up antibodies. These are substances that may make you immune. Vaccines can make you immune to a disease without having it. Your body also fights germs in other ways.

Antiseptics, antibiotics, and vaccines help us stay healthy. Doctors use X rays to help them fix broken bones. These and many other technologies have helped people live longer lives. There will be others.

Unit 6

You Know A Great Deal

A. Choose the term that makes each sentence correct. Then write the letter of the term you choose in your science notebook.

1. To listen to your heart, the doctor uses
   a. a stethoscope **b.** an X ray **c.** a microscope
2. A disease caused by a virus is
   a. anthrax **b.** tuberculosis **c.** measles
3. The average length of life today is
   a. 40 years **b.** 75 years **c.** 100 years
4. Cells in your body that move to bacteria in a cut are
   a. stomach acid cells **b.** white blood cells **c.** red blood cells
5. A body defense against the germs that get into your nose and mouth is
   a. cilia **b.** skin **c.** mucus
6. When you get either kind of vaccine against polio, your body quickly makes
   a. antibodies **b.** antibiotics **c.** antiseptics
7. If you are 130 centimeters tall, for you 130 centimeters is
   a. normal **b.** average **c.** wrong
8. Soon after you get a vaccine against measles, you
   a. get measles **b.** become immune **c.** form colonies
9. The rabies and Sabin vaccines are made from
   a. live viruses **b.** dead bacteria **c.** weakened germs
10. Penicillin is made from
    a. a mold **b.** an antibiotic **c.** a bacterium

B. Tell how each of these scientists helped people live longer: Lister, Fleming, Jenner, Pasteur, Koch, Salk, Sabin, Roentgen

Finding Out in the Library: Epidemics

Did you ever hear of yellow fever? Yellow fever is a disease that once killed many people. When many people in the same area have a disease at the same time, we say there is an *epidemic.* There was an epidemic of yellow fever when the Panama Canal was first being built.

Perhaps you can look up the history of yellow fever to find out how the epidemic was stopped. You might also find out how other epidemics can be prevented. For example, how can an epidemic of bubonic plague or cholera be prevented?

The use of vaccines has helped prevent epidemics of diseases such as smallpox and polio. Yet you have heard about influenza, or flu, epidemics. Why are there still epidemics of flu?

Find out why vaccines can't be used to stop *all* flu epidemics. Perhaps you will share what you have learned with your classmates.

Books For You:

Bacteria: How They Affect Other Living Things, by Dorothy Patent, published by Holiday House, New York, 1980. Bacteria and how they act on other living things make an interesting story.

Who Keeps Us Healthy? by Caroline Arnold, published by Watts, New York, 1982. By reading this book, you can explore people in medicine who work to keep you healthy.

Health and Medicine, by Neil Ardley, published by Watts, New York, 1982. This book describes how new technologies will change medicine and your health in the future.

The Year Is Not Over

You are not the same person you were a year ago. Surely you have grown. You have changed because of the things you have learned.

You now know more about the needs of living things–air, water, light, warmth, clothing, and shelter. Of course, green plants make food. And your growth and energy depend on the kind of foods you eat. You know the vitamins, minerals, and other nutrients you need. How important is it for you to have a good diet?

Actually, when you have a good diet, you are protecting your health and your life. You are protecting yourself from diseases, such as beriberi and scurvy, that come from a poor diet.

Other diseases, such as polio and measles, are caused by germs. You can protect yourself from many germ diseases by vaccinations. You are very lucky. You can expect to live longer–about 35 years longer–than people did 120 years ago.

Doctors and other people interested in your health use the discoveries of science. They use new machines and new substances. That is, they use new technologies. Science and technology have helped to give us healthier, longer lives.

Matter and Energy for Life

Science and technology have given us the modern farm. Our farms not only supply us with food for life. They also supply us with some matter for our clothing. The sea supplies us with food. And it supplies us with mineral matter as well. The land supplies us with matter–coal and oil–we use for fuel.

The energy from these fuels and from electricity provides light and heat. The energy from electricity and gasoline are needed for cars, buses, and tractors. Speeding molecules, of elements and compounds do work in our steam engines.

You have begun to know how science and technology play a part in your life and your environment. Surely you know that your life and your environment are precious indeed.

Science Vocabulary

In this vocabulary, the page number after each term shows where it is used first.

antibiotic–a substance, made by another living thing, that helps the body destroy many bacteria, 272

antibody–substance made by the body; acts against certain germs that get into the body and cause disease, 276

antiseptic–a substance that helps to stop bacteria from growing outside the body, 269

atom–the smallest bit of which all matter is made, 19

average–number that is determined as the result of several trials, as pulse rate or weight, 291

axis–an imaginary line through the center of the Earth, around which it turns, 115

bacteria–one-celled, plant-like organisms that are not green; some cause disease, 38

carbohydrates–sugars and starches that give your body energy, 231

cell–the smallest living unit of any living thing, 213

cell membrane–thin, outer layer around an animal cell; thin layer just under the cell wall of a plant cell, 214

cell wall–the outer layer of a plant cell, 214

change of state–a change in the form of matter, such as solid to liquid or liquid to gas, 13

chemical change–a change in which a substance breaks down or builds up into another substance; the molecules are changed, 178

chemical energy–the stored energy in fuels and foods, 177

chlorophyll–the substance in leaves that makes them green; used by plants to make food, 215

chloroplast–tiny green body in the cell of the leaf of a green plant, 214

cilia–very tiny hairs that line the windpipe, 265

classify–to group together things that have like properties, 10

colony–a group of bacteria that stick together, 259

compound–substance made up of two or more elements, 25

condense–change from a gas to a liquid, 96

confirm–to repeat the experiments of other people and get the same results, 47

current, or **electric current**–a steady flow of electrons through a wire, 130

cylinder–in a steam engine, the tube in which the piston moves up and down, 188
cytoplasm–fairly clear matter between the nucleus and cell membrane of a cell, 214

diet–all the foods that you eat or drink, 230
digest–break down food so the body can use it, 266
disease–sickness, 38; caused by lack of certain nutreints, 236; caused by germs, 257
dissolve–to mix a substance completely in a liquid, as sugar in water, 37
distilled water–water from which minerals have been removed, 96

electricity–a flow of electrons, 126
electromagnet–the magnet produced when an electric current flows through a coil of wire, 140
electron–a tiny particle that whirls around the nucleus of an atom, 128
element–substance made up of only one kind of atom, 20
energy–the ability to do work, 173
engine–a machine that changes other kinds of energy into mechanical energy, 186
environment–everything, both living and nonliving, around you, 10
evaporate–to change state from a liquid to a gas; as liquid water changes to water vapor, 36
evidence–a fact or observation that shows whether or not a statement or idea is correct, 31
expand–get larger; take up more space, 160

fats–nutrient in meats and dairy foods; used by the body for energy, 232
fiber–a thread that machines can spin and weave into cloth, natural, 58; laboratory, 66
force–a push or a pull, 169
fossil–print or actual remains of plant or animal that lived long ago, 75
fuel–a substance, such as coal, oil, or gas, that is burned to give off heat, 71

gas–matter that has no shape and spreads to fill whatever it is in, 7

hypothesis–a possible explanation of an object or event that should be tested, 271

immune–to have antibodies that prevent your getting a certain disease, 276

limestone–a rock formed from layers of shells pressed together and hardened, 83
liquid–matter that has no shape of its own, but takes the shape of whatever it is in, 7

matter–anything that has weight and takes up space, 6
mechanical energy–the energy of moving things, 194
minerals–substances found in small amounts in soil, water, and food, 37; needed for growth by plants, 206; needed by people, 235
mixture–two or more substances put together, but the substances are not changed, 21
model–something built or designed to explain an object or event, 86
molds–small plants without chlorophyll that grow on other living things, 270
molecules–the smallest part of a substance that has the properties of that substance, 152
mucus–sticky substance made by special cells inside the nose, mouth, and windpipe; traps bacteria, 264

neutron–one of the tiny particles in the nucleus of an atom, 128
niacin–vitamin that prevents pellagra, 244
normal–usual for you; such as your height or pulse rate, 290
nucleus–the central part of an atom, 128; the body inside a cell that controls its actions, 214
nutrients–substances needed for growth and health, 230

observe–watch an object, living thing, or event carefully to note any properties or changes, 3

pasteurization–the use of heat and quick cooling to keep germs from multiplying, 281
petroleum–a dark, thick liquid that comes from the Earth; also called crude oil, 81
physical change–a change in which a substance changes, but its molecules stay the same, 178
piston–in a steam engine, the plug-like object inside the cylinder, 188
polluted–contains bits of solid matter and other wastes, 33
porous–describes a substance, such as sandstone, that has spaces or pores in it, 85
predict–to tell ahead, 2
property–something about matter that helps determine what that matter is, 9
proteins–nutrient needed by the body for growth and repair, 231
proton–one of the tiny particles in the nucleus of an atom, 128
pulse–beat caused by the flow of blood; can be felt in the wrist, 290
purified–without any disease bacteria, 38
pus–a substance made mainly from dead white blood cells that have destroyed bacteria, 267

reflects–bounces sound or light from a surface, 113
rotate–turn on an axis, 115

sandstone–a rock formed from lay-

ers of sand pressed together and hardened, 83

shadow–a dark area made by an object that blocks the Sun's light, 110

shale–a rock formed from layers of mud pressed together and hardened, 83

solar cell–cell made of silicon that changes solar energy to electricity, 145

solar energy–energy from the Sun, 118

solid–matter that has a definite shape, 7

starch–the kind of food made by most green plants, 218

stethoscope–an object used by a doctor to hear sounds inside the body, 289

substance–solid, liquid, or gas; matter, 19

technology–a way to use the ideas of science to invent and develop new things, 52

theory–an explanation of observations and facts that stands up when tested, 162

thiamine–vitamin in whole grains; helps prevent beriberi, 242

vaccination–shots of a vaccine that make a person immune to a certain disease, 277

vaccine–substance made from dead or weakened germs; makes a person immune to a disease, 278

virus–the tiniest germ (not a cell) that multiplies inside the cells of the body and causes a disease, 274

vitamin–one of the six nutrients the body needs in small amounts to grow strong and stay healthy, 234

vitamin A–vitamin found in dairy foods; needed for healthy skin and good eyes, 249

vitamin B–a group of vitamins, including thiamine and niacin, needed for good health, 248

vitamin C–vitamin found in citrus fruits and some vegetables, prevents scurvy, 246

vitamin D–vitamin made by your skin in sunlight or often added to milk; needed by the body to use calcium, 248

water–a nutrient needed by the body for life; makes up most of the body's weight, 232

water vapor–the gas that water changes into when it is boiled, 12

windpipe–the tube that leads from the mouth to the lungs, 264

white blood cell–cell that moves by itself in the bloodstream; destroys bacteria, 267

work–what is done when a force makes something move, 168

X ray–a ray that goes through skin but not bone; used to take pictures of some parts inside the body, 287

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Illustrations: Page 225(r), 263(t), Howard Friedman; 264, Lisa French; 265(t), 297, Howard Friedman; Represented by Intergraphics, Inc., Tucson, Arizona: 22(c), 28, Christopher Andrews; 44, Karen Tofoya; 73, Judy Nostrant; 78(t), Walter Porter; 82(tl), 82(tr), Nancy Metcalf; 82(b), 83(t), 87(l), 89, 114(bl), 114(br), Walter Porter; 120, Christopher Andrews; 160(l), 160(r), 163(t), 163(bl), 163(br), Bill Roach; 187(b), 188(b), 189(b), John Edwards; 194, Chuck F. Maraschiello; 214(l), 214(r), 225(l), 241(cl), 241(cr), 243, Judy Nostrant; 248(r), Nancy Metcalf; 251, Judy Nostrant; 275, 286, Nancy Metcalf. All other art by Coronado art staff.

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Frontispiece: J. Stuart Edmondson

UNIT 1: Page viii, Walter Chandoha 1984; 1, Photo courtesy of N.A.P. Consumer Electronics Corp., a North American Philips company; 2, Walter Chandoha 1984; 3, Runk/Schoenberger/Grant Heilman Photography; 4(t), Maidhof Brothers Shipware Merchants, photograph by Myles E. Baker; 6(b), E.R. Degginger/Bruce Coleman, Inc.; 9(l), Bruce Curtis/Peter Arnold, Inc.; 9(r), R. Rowan/Photo Researchers; 14(l), Donald Dietz/Stock Boston; 14(r), Cary Wolinsky/Stock Boston; 15(t), Glyn P. Cloyd; 15(bl), N.A.S.A.; 15(br), Peter Arnold; 16, Owen Franken/Stock Boston; 20(c), Brian Parker/Tom Stack & Associates; 25, Grant Heilman Photography; 29(l), Ken Lax/The Stock Shop; 29(r), Owen Franken/Stock Boston; 31, Grant Heilman Photography; 33, Milton Feinberg/Stock Boston; 38, Walter Chandoha; 40(t), Dick Luria/The Stock Shop; 40(b), 41(l), Tom Tracy/The Stock Shop; 41(r), David Aronson/Stock Boston; 43, Runk/Schoenberger/Grant Heilman Photography; 45(l), Courtesy of the Library of Congress; 45(r), Grant Heilman; 46(t), Walter Chandoha 1984; 46(b), Craig Aurness/West Light; 50, Phil Degginger/Bruce Coleman Inc.; 52, Jacqueline Durand (St. Francis Hospital, Evanston, IL); 53, Walter Chandoha.

UNIT 2: Page 58(b), Old Sturbridge Village Photograph by Henry E. Peach; 59(tl), 59(tr), 59(bl), 59(br), 60(tl), 60(tr), 60(bl), 60(br), Charles Kingery Photography; 61(t), Steve Solum/Bruce Coleman, Inc.; 61(b), Alan Pitcairn/Grant Heilman Photography; 62(t), John Colwell/Grant Heilman Photography; 62(b), Hans Pfletschinger/Peter Arnold, Inc.; 63(t), The Bettmann Archive, Inc.; 63(bl), Harry Giglio/The Stock Shop; 63(br), Irving Shapiro/The Stock Shop; 64(tl), Alan Pitcairn/Grant Heilman Photography; 64(tr), National Cotton Council of America; 64(b), Joseph Nettis/Photo Researchers; 66(t), DuPont Company; 66(l), Arthur D'Arazien/The Image Bank West; 69(l), Richard Choy/Peter Arnold, Inc.; 69(r), Photo courtesy Goodyear Tire & Rubber Co.; 70(l), 70(cl), 70(cr), 70(r), Charles Kingery Photography; 71(t), Runk/Schoenberger/Grant Heilman Photography; 72, Courtesy, Field Museum of Natural History, Chicago; 74(t), David Goldstein; 75(l), Grant Heilman; 75(r), E.R. Degginger/Bruce Coleman, Inc.; 78(b), Lee Balterman/Kay Reese & Associates; 79, 80(t), 80(b), Grant Heilman; 81(t), C.B. Jones/Taurus Photos, Inc.; 83(bl), Grant Heilman; 83(bc), E.R. Degginger; 83(br), Grant Heilman; 84(t), Ron Watts/First Light Photographers; 84(b), Menschenfreund/Taurus Photos, Inc.; 85(b), Runk/Schoenberger/Grant Heilman Photography; 87(r), Alan Pitcairn/Grant Heilman, Toronto; 88, 90, Grant Heilman Photography; 91(b), ZEFA U.K.; 92(t), Ken Lax/The Stock Shop; 92(bl), Myles E. Baker; 92(br), Barry L. Runk/Grant Heilman Photography; 93, Grant Heilman; 98, Courtesy of the Library of Congress; 99, John Running/Stock Boston; 100(l), Domsea Farms, Inc., Bremerton, Washington; 100(r), Herb Taylor/Art Resource, NY; 103, Spencer L. McConnell.

UNIT 3: Page 108(t), Grant Heilman; 110, 111(tl), 111(tr), Norman Prince; 113(r), Naval Historical Center; 114(t), Walter Chandoha; 116, E.R. Degginger/Bruce Coleman, Inc.; 117, Norman Prince; 118(t), Walter Chandoha; 118(b), Lee Foster; 121, 125, Solarex Corp.; 133, Jim Pickerell/Camerique; 142(c), Brian Parker/Tom Stack & Associates; 142(b), Runk/Schoenberger/Grant Heilman Photography; 143(l), Courtesy Shelburne Museum, Shelburne, VT; 143(r), Edison National Historic Site/National Park Service/U.S. Department of the Interior; 145, Jean Guichard/Sygma; 146, 148, N.A.S.A.; 149, Grant Heilman.

UNIT 4: Page 152, Smithsonian Institution; 153, John Rawle/Stock Boston; 154(bl), 155(t), 155(c), 155(b), 156(tl), 156(c), 156(b), Stephen Lesberg, Stephen Cook/Jackrabbit Productions, Poway, California; 162, David T. Overcash/Bruce Coleman Inc.; 164(b), Mike Malyszko/Stock Boston; 165, The Bettmann Archive; 166, Steve Lesberg, Stephen Cook/Jackrabbit Productions, Poway, California; 171(tl), Grant Heilman; 171(tr), Russ Kinne/Photo Researchers; 171(bl), Peter Arnold; 171(br), Barry L. Runk/Grant Heilman Photography; 172(b), Stacy Pick/Stock Boston; 173(l), Owen Franken/Stock Boston; 173(r), Grant Heilman; 174(l), Hydro-Turbine Division, Allis-Chalmers Corp.; 174(r), Grant Heilman; 176(t), Barry L. Runk/Grant Heilman Photography; 176(bl), Linda Moore/Rainbow; 176(br), Agway Inc.; 179(t), The Bettmann Archive, Inc.; 179(b), 180(t), 180(b), 181, Steve Lesberg, Stephen Cook/Jackrabbit Productions, Poway, California; 182(t), Olivier Rebbot/Stock Boston; 187(t), 188(t), 189(t), The Granger Collection, New York; 185, Budd Titlow, Naturegraphics; 186, 190(l), Jacqueline Durand; 190(r), Courtesy of Bay Area Rapid Transit District; 191(t), The Granger Collection, New York; 191(b), Courtesy of the Library of Congress; 192(t), The Granger Collection, New York; 192(b), Walter Chandoha 1984; 195, The Granger Collection, New York; 196, Standard Oil Co. (IN).

Unit 5: Page 200, 205, Barry L. Runk/Grant Heilman Photography; 209(b), Grant Heilman; 213(t), 213(b), The Granger Collection, New York; 216(l), 216(r), 217(l), 217(r), Steve Lesberg, Stephen Cook/Jackrabbit Productions, Poway, California; 218(tl), Walter Chandoha; 218(tr), Charlton Photos; 220(t), 222(l), Grant Heilman; 222(r), Alan Pitcairn/Grant Heilman Photography; 223(bl), Lee Foster/Bruce Coleman, Inc.; 223(br), Walter Chandoha; 230, Myles E. Baker; 236(r), David York/Medichrome; 240, World Health Organization Photo; 245, The Bettmann Archive, Inc.; 247(l), Dan McCoy/Rainbow; 247(r), Reggie Tucker/Taurus Photos, Inc.; 248(l), Walter Chandoha; 252, Norman Prince; 253, Walter Chandoha.

UNIT 6: Page 256, Butler Institute of American Art, Youngstown, Ohio; 258(tl), Runk/Schoenberger/Grant Heilman Photography; 258(tr), Martin M. Rotker/Taurus Photos, Inc.; 258(b), Runk/Schoenberger/Grant Heilman Photography; 259(t) 1984 Martin M. Rotker/Taurus Photos, Inc.; 259(bl), 259(br), 260(t), 260(tc), 260(bc), 260(b), Charles Kingery Photography; 26 (tl), Dan McCoy/Rainbow; 261(tr), (bc), (br), Jacqueline Durand; 261(bl), Ron Sherman/Camerique; 263(b), Charles Kingery Photography; 265, Mary K. Brown, MT, ASCP; 266, The Bettmann Archive; 267(l), 267(c), 267(r), Lennart Nilsson, A CHILD IS BORN, Dell Publishing Co., Inc., New York; 268(t), 268(c), 268(b), Charles Kingery Photography; 269(r), 270(b), 271(l), 271(r), 1984 Martin M. Rotker/Taurus Photos, Inc.; 272, The Bettmann Archive, Inc.; 273(c), 1984 Martin M. Rotker/Taurus Photos, Inc.; 273(l), Charles Kingery Photography; 274, 276, Centers for Disease Control; 278, Dan McCoy/Rainbow; 279, 280, The Granger Collection, New York; 281, The Bettmann Archive, Inc.; 282(t), L.V. Bergman & Associates; 282(b), The Granger Collection, New York; 283, Science Source/PR; 284(l), O. Lee D. Simon/Science Source/PR; 284(r), Omikron/Science Source/PR; 185(l), 285(r), Jacqueline Durand (St. Francis Hospital, Evanston, IL); 287, 1984 Martin M. Rotker/Taurus Photos, Inc.; 288(t), The Bettmann Archive, Inc.; 288(b), L.V. Bergman & Associates; 294(b), Ann McQueen/Stock Boston; 295(l), Courtesy of the Library of Congress; 295(r), Frank Siteman/Stock Boston; 296, Tom Tracy/Medichrome; 298, 299, Dan McCoy/Rainbow; 301, The Bettmann Archive; 310, Camerique; 311, San Diego Gas & Electric.

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